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ERRATA.

Page 151, line 22 from top, for "*Acanthodermia*" read *Acanthodesmia.*
— 170, lines 22 and 31 from top, for "*Haliodiscus*" read *Heliodiscus.*
— 432, line 16 from top, *for* "pore-arms" *read* pore-areas.
— 434, lines 8 and 9 from top, } *for* "Barnes" *read* Barnard.
— 435, line 18 from bottom, } *for* "Barnes" *read* Barnard.
— 440, — 19 from bottom, *delete* "ECHINANTHUS TESTUDINARIUS, *Gray*."
— 448, — 14 from bottom for "OPHIOTRICHDÆ" *read* OPHIOTRICHIDÆ.
— 482, — 9 from bottom, *for* "Limogonus" *read* Limnogonus.
— 486, — 10 from top, "antennis gracillimis corporis æquilongis" *should be* antennis gracillimis ⅔ corporis æquilongis.
— 688, — 9 from top, *for* "CAMPOPHAGA" *read* CARPOPHAGA.

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On the Conditions favouring Fermentation and the Appearance of Bacilli, Micrococci, and Torulæ in previously Boiled Fluids.

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[Read June 21, 1877.]

Contents.

I. *Introductory Remarks.*

My object in the present communication is fourfold. First, I wish to make known in detail certain experimental conditions which I

have found to be highly favourable to the development of fermentation in boiled fluids; secondly, to record fresh instances of the occurrence of fermentation in boiled acid fluids; thirdly, to bring forward certain crucial evidence bearing upon the disputed interpretation of the fertility of boiled neutral or faintly alkaline fluids; and fourthly, to record fresh instances of the fermentation of guarded neutral fluids after they have been heated to 110° C. and upwards.

The investigations recorded in the present communication have been made principally with boiled urine, which will, when securely guarded and kept at a temperature of 77°–86° F. (25°–30° C.), remain free from all signs of turbidity from the appearance of organisms, as Pasteur, Lister, Roberts, Tyndall, and others have ascertained. The testimony of previous investigators on this subject is unanimous.

M. Pasteur, speaking of sweetened yeast-water and of urine, says*:—"Nous avons reconnu que ces liquides, portés à la température de l'ébullition à 100° pendant deux ou trois minutes, puis exposés au contact de l'air qui a subi la température rouge n'éprouvent aucune altération." The latter of these fluids may remain, he says, indefinitely, "sans éprouver d'autre altération qu'une oxydation lente de la matière albumineuse," and this even "à la température de 25° à 30°, température si favorable à la putréfaction de l'urine."

Prof. Lister† calls forcible attention to experiments with boiled urine in support of the germ theory, its continued barrenness, when protected after boiling, being the invariable result in his hands. In regard to any organisms and their germs which it might contain, he says:—"It is necessary to maintain the elevated temperature (212° F.) for about five minutes to ensure complete destruction of their vitality."

Dr. William Roberts‡ mentions healthy and diabetic urine as being amongst the easiest fluids to sterilize, "three or four minutes' boiling" sufficing, as he says, to bring about this result and cause the liquid to remain permanently barren when kept at temperatures ranging between 60° and 90° F.

Prof. Tyndall§ also, in 1875, found five minutes' boiling invari-

* Ann. de Chimie et de Phys. 1862, t. lxiv. pp. 58 et 52.
† Introductory Lecture delivered in the University of Edinburgh, 1869, p. 19.
‡ Phil. Trans. vol. clxiv. pt. 2, p. 461.
§ Phil. Trans. 1876, vol. clxvi. pt. 1, p. 42.

ably sufficient to sterilize urine when it was subsequently exposed only to a "moteless air." Indeed, in regard to experiments made with "*urine*, mutton, beef, pork, hay, turnip, tea, coffee, hops, haddock, sole, salmon, cod-fish, turbot, mullet, herring, eel, oyster, whiting, liver, kidney, hare, rabbit, fowl, pheasant, grouse," amounting in all to several hundreds, five minutes' boiling was always found sufficient to produce complete sterilization.

If, then, we omit from consideration those instances of "smouldering fermentation"* in which, whilst the bulk of the fluid remains clear, organisms are found mixed with sedimentary matter slowly increasing in amount at the bottom of the vessel, and confine ourselves solely to cases of *well-marked fermentation* characterized by the supervention of unmistakable general turbidity due to the multiplication of ferment-organisms, we shall have to deal with a comparatively simple problem. There will in such cases be no room for doubt as to whether or not the experimental fluids contain organisms; in the great majority of instances these will be so numerous that even a tyro with the microscope could find them. Neither will there be room for the supposition that the organisms which are found are "dead and have been there all the time." Dead organisms cannot by any stretch of fancy be supposed to multiply so as to make a previously clear fluid turbid.

If, then, taking the fresh acid urine of a healthy person, and boiling it so as to kill any organisms and germs which it may contain, one is able, merely by subjecting this sterilized fluid to certain physical and chemical influences, to cause it to ferment in an unmistakable manner and swarm with living Bacteria, such a procedure and its sequence could scarcely be otherwise regarded than as a demonstrable proof of the truth of the physico-chemical theory, and as an equally cogent disproof of M. Pasteur's exclusive "germ theory" of fermentation. The same experiments would coincidently afford clear evidence as to the occurrence of so-called "spontaneous generation"†.

* Proc. Roy. Soc. vol. xxi. (1873) pp. 333 & 337.

† This term will, I hope, after a time be discarded, because under it two distinct processes have been included, which are liable to be improperly confounded with one another. One process, which I designate by the word *archebiosis*, includes the actual origination of living matter, its *de novo* formation; whilst the other, *heterogenesis*, signifies a particular transformation of some already existing living matter.

In the experiments of this kind now to be described I have had recourse to the aid of a stimulating physical influence (viz. heat), which has been much more sparingly resorted to by other investigators, as well as by myself, on previous occasions; I have also made use of certain chemical agents (viz. oxygen and liquor potassæ) under conditions as novel as they are stringent. In several respects, indeed, the experiments about to be recorded differ much from those hitherto made for the purpose of throwing light upon the two correlated and much vexed questions, as to the conditions of origin of fermentations, and as to the present occurrence or non-occurrence of archebiosis.

Whilst I have been careful to call to my aid all those conditions and influences which were admissible and might, within the narrow boundaries of a strictly trustworthy experiment, be supposed to favour the process of fermentation, I have also neglected no precaution, however trivial, which has hitherto been insisted upon as needful for the completeness of the preliminary destructive process. I have stedfastly sought to destroy every trace of pre-existing living matter within the glass-bounded field of experiment, without unnecessarily deteriorating the mere organic matter. With this end in view, in a large proportion of the experiments the precaution has been taken, after boiling the fluids and hermetically sealing the vessels, to immerse them in an inverted position in a can of boiling water for 5″–15″. By this means the portions of the retort- or flask- walls which, during the boiling over the flame, are only exposed to brief contact with the boiling fluid or to steam, come during the boiling in the can continuously into contact with the infusion itself heated to 212° F. An interval of three quarters of a minute must, in these cases, be allowed to elapse after the sealing of the tip of the retort or flask before it is inverted and plunged into the boiling water, in order that this over-heated tip may not crack by coming into contact with the fluid within. This accident will also be diminished in frequency by long practice, and by careful sealing in such a manner as to avoid any inbending of the glass. When a minute crack has occurred, it is always rendered obvious, during the period that the vessel is cooling, by a line of small air-beads starting therefrom. Such a vessel must of course be rejected, or only kept for observation as an air-contaminated specimen.

A few words are desirable as to the best mode of subjecting the experimental fluids to any given generating temperature.

In my earlier experiments, as well as in a few of those which were made in connexion with this research, I had recourse to the method of immersing the experimental vessels in a large beaker or pan containing water and a thermometer. The temperature of the water in such a vessel was raised to the required extent by a spirit-lamp or gas-flame. But without frequent watching and great care this method is almost sure to entail greater fluctuations of temperature than are at all desirable. I have therefore now for some time had recourse to the ordinary incubator employed in physiological laboratories, supplemented by one of the ingenious and valuable gas-regulators* devised by Mr. F. J. Page, B.Sc. This combination of apparatus gives us a warm chamber which may be maintained almost indefinitely at any given temperature. The variations, extending over several weeks, may with care never exceed one degree Fahrenheit. In carrying out this research I have latterly found it convenient to employ two incubators, in one of which the experimental fluids could be exposed to a very high generating temperature, and in the other to moderately high temperatures.

It is more than ever necessary to employ an efficient heat-regulator when the generating temperature to which the fluid is to be subjected is very high, because an accidental rise even of a few degrees might prove detrimental to the initiation of fermentative changes—more especially if the fluids remained exposed to this unduly elevated temperature for several hours. A caution is needed, however, as regards the mode of using the incubator in these experiments. A thermometer whose bulb is exposed to the air of the chamber does not afford a correct indication of the the temperature of an experimental fluid contained in a closed glass vessel which has been resting for several hours upon its floor. The temperature of the fluids would probably always be higher than that of the air, which the thermometer registers. A much more correct means of judging of the actual temperature of any experimental fluids contained in the incubator is obtained by allowing the end of the thermometer, like the experimental vessels, to rest upon the floor of the incubator. It is of importance to regulate the temperature of the incubator in accordance with the reading of a thermometer thus disposed, since in the absence of such a precaution the experimen-

* Described in Proceed. of Chem. Soc., Jan. 1876, vol. i, p. 24.

tal fluids would mostly be exposed to temperatures higher by 7°–10° F. than had been intended—as I have ascertained by actual trials.

II. *Heat as a Promoter of Fermentation.*

The great dependence of the processes of fermentation upon heat is one of the commonplaces of science. It is known, for instance, that nearly all such processes, if not all, cease at about 41° F. (5° C.), and, speaking generally, that they increase in energy with successive increments of heat till a temperature of about 86° F. (30° C.) is reached. It has hitherto been considered that temperatures between 77° and 95° F. (25° and 36° C.) were those most favourable for fermentations. The upper limits of favourable temperature, however, had not been carefully defined; and this was the case especially in regard to the occurrence of fermentation in previously boiled fluids.

In previous experiments of this class no one had, so far as I am aware, designedly made use of a generating temperature above 100° F. (38° C.); the heat employed by some investigators has indeed been only too frequently below 77° F. (25° C.). Previous to the month of August 1875, I had myself never purposely employed a generating temperature above 100° F.; but early in that month I discovered that some boiled fluids which remained barren at a temperature of 77°–86° F. would rapidly become turbid and swarm with organisms if maintained at a temperature of 115° F. (46° C.). This important fact was ascertained whilst experiments were being made with hay-infusions and milk which had previously been subjected to destructive temperatures considerably higher than 212° F.

Soon after I discovered that an incubating or generating temperature as high as 122° F. (50° C.) may be had recourse to with advantage in dealing with some fluids. Organic infusions which would otherwise have remained barren and free from all signs of fermentation, have under its influence rapidly become corrupt and turbid. But although the high temperature proves to be so favourable for initiating chemical changes of a fermentative type in some, it must not be assumed that it would be equally provocative in respect to all organic fluids. The conditions most favourable for the initiation of such changes must be separately studied for each kind of fluid with which experiments are being made, since important specific differences may be encountered. I have already, however, ascer-

tained that this high temperature of 122° F. (50° C.) is just as favourable for the fermentation of milk and of hay-, turnip-, and other vegetable infusions, as it is for urine.

Shortly after my first announcement of this fact in June 1876*, it was made known by Professor Cohn† that Dr. Eidam had also discovered that certain organisms would grow and multiply rapidly at this high temperature in infusions of hay, though it was one which proved fatal to *Bacterium termo*, *Torulæ*, and other allies. He moreover stated that the organisms found under these contions were invariably *Bacilli*. To this latter point I shall have to return in a subsequent part of this communication.

What I have now to say concerning the simple influence of 122° F. as an initiator and promoter of fermentation in boiled fluids may be comprised in a very few words.

Where the initial acidity of urine, is such that it requires less, or not more than 6 minims ($1\frac{1}{4}$ per cent.) of liquor potassæ‡ to the ounce (of 480 minims) to ensure its neutralization, I have found that such a fluid after it has been boiled 2″ over the flame and 5″–10″ in a can of boiling water, will almost invariably ferment in 15–48 hours if kept at a temperature of 122° F.§, though it will rarely or ever undergo this change at a temperature of 77°–86° F.

Where the acidity corresponds to 7 minims of liquor potassæ per ounce, a specimen of urine, boiled as above, sometimes ferments and sometimes does not. A urine whose acidity equals 8 minims of liquor potassæ per ounce (nearly $1\frac{3}{4}$ per cent.) has only been known to ferment on two or three occasions out of numerous trials; and where the acidity has been higher than this, the fluid has invariably remained barren under the stimulus of a temperature of 122° F. acting alone—that is, without the additional aid of other promoters, such as oxygen or liquor potassæ.

When a urine whose initial acidity equals seven or eight minims of liquor potassæ per ounce has fermented after boiling, this has been sometimes attributable to the fact that the specimen in ques-

* Proceedings of Royal Society, No. 172, vol. xxv. p. 149.

† Beiträge zur Biolog. der Pflanzen, Bd. ii. Hft. 2, 1876, p. 268.

‡ A 5·84-per-cent. solution (see p. 16).

§ I have, however, found a diabetic urine of five minims of acidity (sp. gr. 1040) invariably remain pure after a short boiling, even when kept at a heat of 122° F.

tion has deposited phosphates before it reached the boiling-point, and thus has had its acidity lowered*.

The behaviour of a specimen of urine prepared in the manner above indicated has several times been tested, first under the influence of a lower temperature and afterwards under that of the higher. Thus, to take an example from my note-book, two specicimens of a urine whose sp. gr. was 1025, and whose acidity was equivalent to five minims per ounce of liquor potassæ, were kept at a temperature of 80° F. for eight days without undergoing any change; but within twenty-four hours after they had been transferred to a temperature of 122° F. they were in full fermentation.

The powerfully stimulating influence of a temperature of 122° F. may also be easily seen in another way. In addition to causing certain fluids to ferment which would otherwise remain barren at ordinary temperatures (77°–86° F.), it shows its influence upon those fluids which will ferment at these lower temperatures, by bringing about such a change with much greater rapidity.

No fluid serves better for showing these relative effects than urine which has been neutralized with liquor potassæ before the process of boiling, because, though it will mostly ferment at the lower incubating temperatures, it does so with difficulty and only after many days. Thus I have found that a urine whose acidity required ten to twelve minims of liquor potassæ per ounce for neutralization, would (after such admixture and an ebullition of five minutes' duration) not ferment under 12–15 days, if kept at a temperature of 70°–73° F., though such a change would show itself in 15–30 hours at a temperature of 122° F.†

In previous paragraphs, when speaking of the degrees of acidity of urine which would permit of its fermenting after ebullition at a temperature of 122° F., I have always referred to its initial acidity—its acidity, that is, previous to the process of ebullition, not

* See p. 53.

† Whilst such comparisons are so easily to be made by others, and will so plainly show the superior efficacy of a temperature of 122° F. in initiating fermentation, one can only marvel at the attempts of Prof. Tyndall and of Dr. Roberts to throw discredit upon my statements on this subject. It is to me surprising that Dr. Roberts (see Proceed. of Royal Soc. No. 176, vol. xxv. p. 456) could have resorted to so unscientific a method of testing the truth of such a simple statement. The method adopted by Prof. Tyndall was perhaps not at all more appropriate, though, as usual, he is very sparing in his narration of details (Phil. Trans. 1876, Part 1, p. 57), so that it is more difficult to be quite cer- in what he did.

after this event. This is a distinction of considerable importance. If we take a urine whose acidity equals 10–15 minims of liquor potassæ per ounce, if we boil it and subsequently keep it for a long time in the incubator at 122° F., it remains barren; and yet on opening the vessel and testing its acidity we may find that this has been reduced to five, four, or two minims per ounce; it may even be neutral*. The occurrence or not of fermentation in any given specimen of urine at 122° F. is, therefore, not a question of its less or greater acidity at some period subsequent to the process of boiling, but of its degree of acidity at the time of ebullition itself. Effects are produced by the heat plus the large amount of acid, which are not produced by the heat and a smaller amount of acid; and these effects may be merely germicidal, or they may be more purely chemical in their nature †.

III. *Oxygen as a Promoter of Fermentation.*

Early in the present century Gay-Lussac assigned to oxygen an all-important role in the initiation of fermentative changes. He and his followers regarded the oxygen of the atmosphere as the "primum movens" in all fermentations—a doctrine which, though it is in the present day generally admitted to be too exclusive, was for a long time almost universally accepted. But even now no one questions the fact that oxygen acts in common with other agencies as a powerful inciter of fermentation and putrefaction.

I freely admit this latter proposition, although I have brought forward some evidence tending to show that certain fermentative processes may be initiated just as freely (or rather more so) in closed vessels from which almost the whole of the air has been expelled by boiling, as in others in which atmospheric air, and consequently oxygen, is present in much larger quantity ‡.

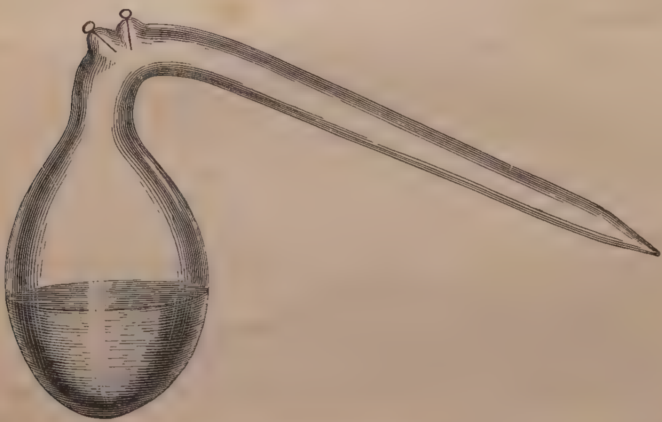
* See further on, at page 47, footnote *.

† The fact itself is shown by the different influence of potash upon an acid urine according as it is added before or after the process of boiling. A urine of twelve minims' acidity to which six minims per ounce of liquor potassæ has been added before boiling, will ferment freely under the influence of 122° F.; but if this same urine had been boiled in its fully acid state, and the six minims per ounce of liquor potassæ were added afterwards, no such result would follow; or if it ever did ferment, it would be only rarely and after an interval of many days. This is an anticipation of a subject to be considered further on, but which it is useful to note here.

‡ 'Beginnings of Life,' Appendix C, expts. viii., ix., xiv., xv., xviii., xx., xxvi., xxx., xxxiii., and xxxvi.

The explanation of this fact is probably to be found in the supposition that, in starting the fermentation of some fluids, diminution of pressure may be of as much or even of more importance than contact with free oxygen. This appears to hold good for hay- and turnip-infusions. With some other fluids the influence of oxygen seems to be decidedly more potent as a co-initiator of fermentation than that diminution of pressure which is brought about by hermetically sealing the vessel before the fluid within has ceased to boil. Urine is an example of this latter class.

Fig. 1.



Retort with platinum electrodes.

I have made only a few experiments bearing upon the effect of adding oxygen to boiled urine contained within retorts from which air has been expelled; but to these I now refer, partly because of the nature of the results obtained, though principally because I shall be able to call the attention of other investigators to a method which may hereafter prove capable of throwing much additional light upon the conditions favouring the fermentation of other boiled fluids, and perhaps upon the morphological variability of ferment-organisms—since it enables us at will to modify the constitution of the fluid and the pressure to which it is subjected, whilst we also expose it to varying amounts of oxygen.

In order to ascertain the effect of the addition of oxygen gas to boiled urine contained in a sealed vessel from which air has been expelled by boiling, I have made use of a retort (fig. 1), into the

shoulder of which two platinum electrodes have been inserted. Such a retort may be charged with acid urine; the urine may be boiled for the requisite time; and its drawn-out neck may be hermetically sealed whilst the fluid is still boiling. After the fluid has cooled, or after an interval of some days, we can easily liberate a quantity of oxygen and hydrogen gas within the closed vessel by connecting its platinum electrodes with the poles of a suitable galvanic battery. We are thus able, by comparison, to ascertain whether the addition of these gases and the other alterations involved, exercise any appreciable effect in hastening the process of fermentation or in otherwise modifying its course or its products.

From the few experiments which I have already made with the view of throwing light upon this point, it would seem that the addition of oxygen exercises the most marked influence when it is allowed to operate in conjunction with liquor potassæ liberated from its tube almost immediately afterwards.

I have as yet made only a few experiments in which the influence of oxygen without liquor potassæ was tested with acid urine. In these, closed retorts were employed which had been sealed after the fluids had been boiled for six minutes, oxygen was liberated by electrolysis, and the vessels were subsequently kept at 122° F. The results of the experiments were as follows:—

In one of these trials with a urine whose spec. grav. was 1025, and whose acidity was capable of being neutralized by five minims of liquor potassæ to the ounce, the fluid became turbid after the expiration of six hours, although, before the oxygen had been liberated, this retort had been exposed to a temperature of 80°–90° F. (21–26° C.) for eight days without its contained fluid undergoing any appreciable change.

In three experiments with a specimen of urine whose specific gravity was 1026, and whose acidity was equivalent to eight minims of liquor potassæ to the ounce, no general turbidity was noticed, though towards the end of the second day a very distinct amount of flocculent deposit was seen in each of the vessels*. On opening one of these retorts at once (after shaking its contents), Bacilli of different sizes, with progressive and rotatory movements, were found, some of which had grown into filaments, though they were not very numerous in each field. The fluid in the two other retorts underwent no very appreciable change during the next

* No cloudiness of the fluid had been produced during the process of boiling.

four days; and when these vessels were opened their fluids were also found to contain a sparing number of active Bacilli of different lengths.

In two other experiments, in which the urine was slightly more acid, requiring 9 minims of liquor potassæ to the fluid-ounce for neutralization, a deposit formed more slowly and was smaller in amount. It was ascertained to consist principally of abortive crystalline matter; and the Bacilli, though present, were scarcer still—not more than one or two being seen in each field of a No. 9 "immersion" object-glass of Nachet, with a No. 3 eyepiece.

Finally, in two experiments with a urine of extremely high acidity (represented by 20 minims of liquor potassæ to the ounce) and a specific gravity of 1026, there was no appreciable naked-eye change after eight days, other than the presence of a very slight amount of sediment in each. On subsequently opening the retorts, no organisms were found in their respective fluids, and the scanty sediment was ascertained to consist of more or less abortive crystals together with amorphous mineral matter.

A few other experiments in which the liberated oxygen was brought into play almost simultaneously with liquor potassæ, will be subsequently referred to (p. 25).

IV. *Liquor Potassæ as a Promoter of Fermentation.*

It has been well known for some time that the presence of alkalies, and especially potash, favours the occurrence of fermentation or putrefaction in suitable media. Gerhardt, for instance, in his 'Chimie Organique,' said*, "Many bodies which, alone or in the moist state, do not oxidize on exposure to air, undergo combustion as soon as they are subjected to the influence of an alkali. Thus pure alcohol can be kept exposed to the air indefinitely without becoming acid; but when it is mixed with a little potash, it quickly absorbs oxygen and becomes converted into vinegar and a brown resinous matter. It is clear from this that potash ought to favour certain fermentations." A little further on †, the same eminent chemist thus gives expression to a more familiar, though related, fact:—"It is known that meats and vegetable substances pickled in vinegar are preserved from decomposition at least for a certain time. . . . . . The majority of acids produce the same effect as vinegar."

The action of alkalies and of acids in favouring and retarding

* Tome iv. 1856, p. 547. † *Loc. cit.* p. 556.

fermentative changes has of late years become familiar to many workers, and is very generally recognized, more especially since attention was prominently called to one side of the subject by Pasteur in 1862 *. He found that some neutral or slightly alkaline boiled fluids would ferment more easily than otherwise similar boiled acid fluids, though he made no observations as to the comparative influence of acids and alkalies upon unboiled fluids. Taking into consideration a limited group of facts only, he endeavoured to account for them in a manner which, if not adverse to, did not sufficiently appreciate, the wider point of view of Gerhardt.

Yet this wider point of view and the relative influence of acids and alkalies may be demonstrated with the utmost ease, as I pointed out in 1870 †. Thus, if two portions of an acid infusion are exposed side by side at a temperature of 77° F. (25° C.), fermentation may be made to occur earlier, and to make more rapid progress in either of them at will by the simple addition of a few drops of liquor potassæ; and, on the other hand, if a neutral infusion be taken and similarly divided into two portions placed side by side under the same conditions, fermentation may be retarded and rendered slower in either of them at will, by the simple addition to it of a few drops of some strong acid.

A neutral or faintly alkaline organic solution can in this way be demonstrated to possess a higher degree of fermentability than an otherwise similar acid organic solution. It seems therefore obvious that the higher tendency to undergo change of these fluids might be less easily stifled than the lower tendency possessed by acid infusions, and consequently that the changes capable of taking place in boiled neutral and acid infusions respectively might be very different; the previous boiling, that is, might not prevent the higher fermentability of neutral infusions from still issuing in fermentation, though it might much more frequently extinguish the lower fermentability of acid infusions.

Numerous experiments by different observers have now demonstrated the correctness of this inference. Boiled acid infusions, guarded from contamination, mostly remain pure and barren if kept at or below 77° F. (25° C.), though some of the same infusions similarly treated, except that they have been rendered neutral by the addition of an alkali, will oftentimes become corrupt

* Ann. de Chimie et de Physique, tome lxiv. p. 58.

† Nature, July 14, p. 227.

and swarm with organisms even at this comparatively low temperature. When subjected to a high temperature (122° F.), these previously boiled neutral infusions will still more frequently ferment, though this very strong stimulus will (as we have seen) also cause some otherwise barren acid infusions to ferment and swarm with organisms.

In the summer of 1875 I first made experiments with urine to ascertain whether it followed the rule above alluded to—that is, whether, like other acid fluids, its fermentability would be increased by previously neutralizing it with liquor potassæ. This preliminary inquiry was soon answered in the affirmative.

Then came the more important question as to the cause or mode of production of such increased fermentability. For two reasons urine seemed to me to be a fluid specially favourable for use in attempting to throw light upon this problem:—*first*, because of the unanimity of experimenters as to the fact that, when boiled in its acid state and subsequently guarded, it invariably remained barren *; and *secondly*, because the marked acidity of urine would necessitate the use of liquor potassæ in easily measurable quantities, even when providing for the neutralization of such small portions of fluid as are commonly employed in these experiments†.

Two alternative views are possible as to the cause of the fact in question:—(1) It may be due to the "survival of germs" of some of the ferment-organisms in the boiled neutral infusions, as Pasteur asserts; or (2) it may be due to the mere chemical influence of potash in initiating and favouring the molecular changes leading to fermentation, as originally suggested by Gerhardt.

This important question would seem to be so capable of being settled by crucial experimentation as to make it not a little remarkable that no such attempt was ever made by M. Pasteur. Thus, the fluids may be boiled in their acid state so as to kill all their contained germs and organisms, and to these fluids boiled liquor potassæ may be added in suitable quantity ‡. The results of a number of such experiments should be sufficiently decisive to

* This was my own experience also at the time. It was not till a later period that I began to obtain the results with high incubating temperatures, which have already been recorded (p. 7).

† Mostly from 1 to 1½ fluid-ounce has been made use of by me.

‡ A few experiments of this nature were first made by Dr. William Roberts with hay-infusion (Phil. Trans. 1874, vol. clxiv. pt. 2, p. 474).

enable us to fix upon the true mode in which liquor potassæ operates in determining fermentation. If the fluids to which boiled potash is added in suitable quantity still remained barren, then such experimental results would unquestionably favour the first interpretation, viz. that given by M. Pasteur and adopted by other germ-theorists. If, on the other hand, the addition of the boiled liquor potassæ to the urine which has been boiled in its acid state suffices to convert this previously pure fluid into a turbid liquid teeming with ferment-organisms, then it would be conclusively shown that the increased fermentability of neutralized urine was ascribable to the second cause, viz. to the chemical influence of the liquor potassæ in initiating fermentative changes, whatever the precise nature of these early changes may be, whether (*a*) partly vital, or (*b*) at first purely physico-chemical.

Some preliminary experiments were made with an apparatus closely similar to that employed by Dr. Roberts in the very few

Fig. 2.

Plugged Flask with liquor-potassæ tube.

experiments which he undertook with hay-infusion. Small narrow-necked flasks were taken capable of holding nearly 3 oz. of fluid; and each of these was about half filled with a measured amount of fresh unfiltered urine, whose degree of acidity had been previously ascertained by carefully finding the exact number of minims of the liquor potassæ of the 'British Pharmacopœia' which were needed to neutralize 1 ounce of it *. Quantities of liquor potassæ just sufficient to neutralize the amount of urine intended for each flask were then enclosed in a number of glass tubes, each of which had a small bulb at one extremity and a similar bulb near the other end, beyond which it was drawn out as a thin prolongation and bent at an obtuse angle. Each of these tubes was charged by heating it in a flame before immersing its open capillary extremity in the requisite quantity of liquor potassæ, contained in a minute porcelain capsule. When the whole of the measured amount of alkali had thus been forced into the glass tube, this was inverted, and its capillary extremity was sealed in the spirit-lamp flame. Its neck was then wrapped round with cotton-wool, and the tube itself was inserted into one of the flasks in such a manner that the cotton-wool might act as a plug thereto, whilst the capillary extremity of the tube just touched the bottom of the vessel.

The flasks being thus charged and arranged, the urine in its altered acid state was boiled over a flame for five minutes. When the fluid had cooled, the tube was pressed down slightly so as to break off its capillary extremity; and immediately afterwards a flame was applied to the external bulb of the tube, so as to expand its contained air. The measured amount of liquor potassæ was thus expelled into the sterilized urine; and the flask was then placed in an incubator and maintained at a temperature of 104°–113° F. (40°–45° C.)†.

Some tentative experiments were made in this manner with fresh urine whose specific gravity varied from 1020 to 1025, and whose acidity was such that 7–15 minims of liquor potassæ per ounce were required for neutralization. In nearly every case it

* In these first experiments the liquor potassæ was delivered from a subcutaneous injection-syringe, minim by minim when the point of saturation was nearly reached. It may be well to mention that the solution of potash above named has a sp. gr. of 1058, and that it contains 27 grains of caustic potash to the fluid-ounce of water (5·84 per cent.). What I have used has always been purchased from Mr. W. Martindale, of 10 New Cavendish Street, London.

† No higher incubating-temperatures were used in these particular experiments.

was found that the urine became lighter-coloured and turbid in two or three days. Other experiments showed that a slight excess of liquor potassæ tended to retard or even prevent the occurrence of fermentation, though a quantity of liquor potassæ notably below that needed for neutralization was found to be efficacious in inducing it, and that, too, almost as rapidly as if the neutralization had been complete. Even when the liquor potassæ was added in quantity only sufficient for half-neutralization, fermentation still took place in many instances, though in such cases the result was usually delayed for five or six days.

In all these trials it was found that the fluid, when turbid, was not fœtid; its odour was for the most part scarcely at all altered, though at times it was rather more marked than usual. The organisms found in the fermenting urine were in all cases the same, viz. Bacilli, either short, medium size, or in the form of long threads—and not the ferment thought by Pasteur to be the invariable cause of the conversion of urea into ammonic carbonate and water*. Sometimes only the short unjointed rods were found, though more frequently these were mixed with varying amounts of longer Vibrio-like bodies, and with threads such as I and others have generally spoken of as Leptothrix.

The results of the foregoing preliminary experiments induced me to seek other, stricter methods, free from two possible sources of fallacy which might be thought to have influenced the results. Thus, as the whole of the tube containing the liquor potassæ was not immersed in the boiling fluid, it was possible that the heated vapour within the tube was not certainly sufficient to sterilize the small quantity of air also contained within it above the level of the liquor potassæ. It would have been easy to meet this source of uncertainty by boiling the closed liquor-potassæ tubes in a vessel of water for a time before inserting them into the experimental flasks containing the urine. But the other possible source of fallacy would still have remained. It might be said by some that the cotton-wool plug, which hitherto had been deemed to be thoroughly efficacious as a protective barrier between the impurities of the outside air and the boiled fluid, was itself a nidus for germs, some of which, unkilled by the steam of the boiled fluid (by which, of course, the wool has been saturated), subsequently found their way into the fluid within the flask. This objection has been urged by Prof. Tyndall against some experiments made by Dr. William Roberts; and if it is a valid objection (which I very

* Ann. de Chim. et de Phys. t. lxiv. (1862) p. 50.

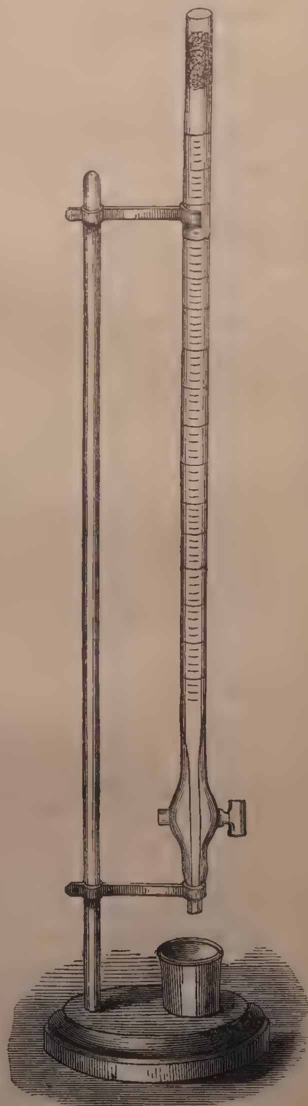
much doubt), there would be an end to the long-established reputation of cotton-wool as a protective filter in such experiments.

To get rid, however, of all doubt of this kind, I determined to repeat the urine and liquor-potassæ experiments with hermetically sealed vessels from which air had been expelled by boiling, and to take the further precaution of boiling the liquor-potassæ tubes before inserting them into the experimental vessels. It was safe at once to resort to such a method, because I had previously ascertained that urine neutralized before boiling would ferment in such closed airless vessels almost, though not quite, as freely as in flasks plugged with cotton-wool. There was, therefore, nothing unduly restrictive in the proposed conditions.

The new mode of procedure which I devised was conducted as follows :—

In the first place a stock of liquor-potassæ tubes had to be prepared beforehand containing convenient amounts of liquor potassæ. Some were charged with 8, others with 10, and others with 12 or more minims. Those containing the same quantity were kept together in separate batches duly labelled and ready for use, as occasion required, according to the degree of acidity of the urine with which experiment was to be made. In order to ensure perfect accuracy in the measurement of the liquor potassæ, I have of late made use of a small burette-tube (fig. 3) graduated to minims and fitted with

Fig. 3.

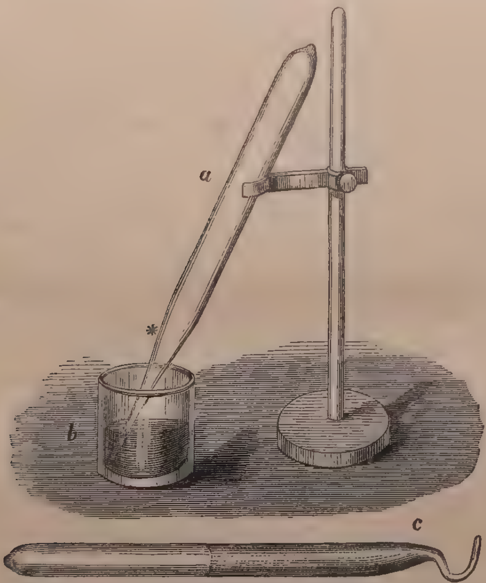


Burette-tube for measuring liquor potassæ.

a stopcock, with which even half-minims can be delivered with ease*.

Having prepared a number of small glass tubes closed at one end and drawn out at the other, I proceed to charge them with measured amounts of liquor potassæ. As in the previous experiments, the liquor potassæ is delivered into a little porcelain pot; and the open capillary extremity of the glass tube, previously well heated in the flame of a Bunsen's burner, is immersed therein. When no more suitable rest is at hand the little porcelain vessel may be placed in the angle between two bottles, so that the upper end of the heated tube inclines against them, partly for support and partly that it may cool more quickly. In two or three minutes, when the whole of the liquor potassæ is forced into the tube, this is to be inverted, and its shoulder, where

Fig. 4.



Liquor-potassæ tubes with capsule and stand.

it begins to narrow (fig. 4,*), is heated in a spirit-lamp flame, so that the tube may be drawn out still more in this situation.

* This little instrument was made for me by Cetti and Co., of 11 Brooke Street, Holborn, London.

Subsequently the end of tube is bent, in the manner shown in the figure (*c*), and then hermetically sealed.

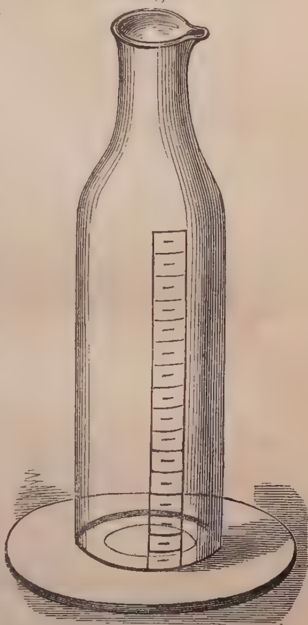
Thus prepared, the tube should be just half full of liquor potassæ. Its length will have been diminished as much as possible; and its tip is so arranged that it may be easily broken off by a slight mechanical shock. These last steps in the preparation of the liquor-potassæ tubes are best carried out with the aid of a very small spirit-lamp flame, as they require to be done slowly and with care. On the one hand, it is necessary that the bent part of the tube should be weak enough to break readily when jerked against the wall of the experimental vessel in which it is afterwards enclosed; and, on the other, it must not be so much weakened as to make it break too easily or be unable to bear the internal strain which it will have to undergo during its immersion in boiling water. This, in fact, is the final stage in the preparation of the liquor-potassæ tubes. A number of them, after they have been hermetically sealed, are to be placed in a suitable vessel containing warm water; and they are then to be raised to the temperature of 212° F. (100° C.) for the period fixed upon. As in these experiments I soon found that the longer or shorter duration of the period of boiling of the liquor-potassæ tubes did not appreciably influence the results, they were, for the most part, boiled for 15″–20″ only—though in many cases it was much longer, and in two or three they were boiled for 2 hours. Thus prepared, the tubes were set aside in compartments labelled according to the number of minims of liquor potassæ which they contained.

A stock of such tubes being ready to hand, experiments may be made at any time. A suitable specimen of fresh urine is to be taken, whose specific gravity is to be ascertained and whose degree of acidity is to be most carefully estimated. This latter process I have carried out by taking exactly 1 fluid-ounce of the urine and adding liquor potassæ to it, minim by minim, from the burette-tube till the point of saturation is nearly reached. Thereafter the alkali has been added in half-minims at a time, and tested between each addition with litmus and turmeric paper so as to make quite sure of the time of complete neutralization*. In order

* It is not unimportant here to add that the test-papers which I have used have been those sold by Mr. W. Martindale, of 10 New Cavendish Street, London. They are similar to the papers used in the wards of University-College Hospital. By careful trial I have ascertained that $\frac{1}{8}$ of a minim of liquor po-

to facilitate this part of the process, I have made use of a lipped measure (fig. 5) having a rather narrow orifice, which can be easily covered by the thumb so as to allow its contents to be shaken for the thorough admixture of each quantity of liquor potassæ with the urine to which it has been added.

Fig. 5.



Lipped measure for admixture of potash.

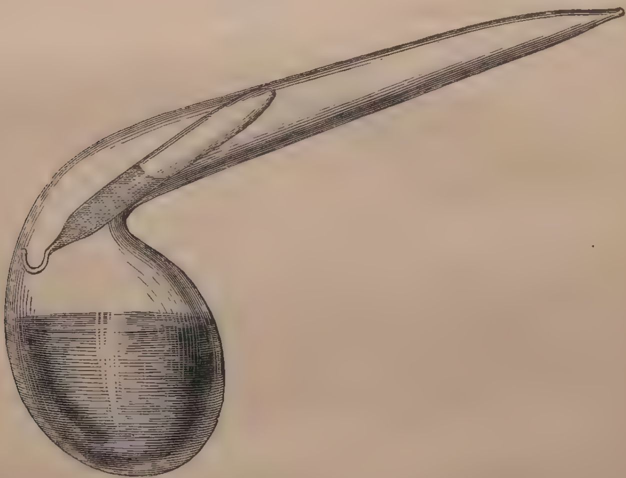
These experiments have hitherto been exclusively conducted with my own urine; and I have generally found that which was passed in the morning before breakfast very suitable for use. This fluid has remained clear after boiling, no phosphates being deposited during the process; its acidity has usually been neutralized by 10–14 minims of liquor potassæ per ounce; and its specific gravity has varied from 1020 to 1025.

When the acidity of the urine with which experiment is to be made has thus been accurately determined, one can easily settle which set of the already prepared liquor-potassæ tubes it will be most convenient to employ. I have generally made use of about 1–1½ ounce of urine for each experiment, and, after

tassæ in an ounce of distilled water may be recognized by the previously *reddened* litmus paper, whilst ⅛ of a minim in the same quantity of distilled water may be detected by the yellow turmeric paper. The latter, though less delicate, gives the most certain indication, especially when a drop of the fluid to be tested is allowed to fall on dry turmeric paper. As the fluid is absorbed by this partly bibulous paper, a faint brown circle is seen for a moment or two when the fluid is very faintly alkaline. The importance of such details as this will be obvious when I say that, last July, urine which I tested in M. Pasteur's laboratory and found to have an *acidity equivalent to* 7½ *minims of liquor potassæ per ounce*, was pronounced by M. Pasteur to be "*légèrement alcalin*," according to the indications of a slightly reddened litmus paper recently used in his laboratory. This was a most surprising difference; and I cannot say yet how far our very different indications hitherto as to degrees of acidity and alkalinity may account for some of the discrepancies between the results of M. Pasteur and myself in the performance of these urine and liquor-potassæ experiments (see Note 1, p. 180, of the 'Comptes Rendus' for July 23, 1877, where M. Pasteur has also something to say on the same subject).—*Sept.* 1877.

numerous trials, have found it best in this series not to provide liquor potassæ sufficient to neutralize the quantity of fluid in the unboiled state, but to make use of liquor potassæ in a closed tube to the extent of two thirds or three fourths of this amount—the former being, on the whole, the safest proportion*. An illustration will make the mode of procedure at this stage clearer. If the urine to be employed has an acidity of 12 minims of liquor potassæ to the ounce, then 1 ounce of it should be placed in each experimental vessel (retort or flask of about 2 ounces

Fig. 6.



Retort used in experiment, as described in text.

capacity); and with it a liquor-potassæ tube containing 8 minims of this fluid should be also inserted, with its narrowed and bent extremity downwards. If, on the other hand, the urine had an acidity of 8 minims of liquor potassæ to the ounce, and only tubes containing this amount of liquor potassæ were at the time available for use, we should then have to place in each experimental vessel $1\frac{1}{2}$ ounce of the urine and one of these 8-minim tubes.

When properly charged, the neck of the retort or flask is to be

* There is reason to believe that conditions other than the acidity of the fluid may subsequently have to be taken into account, since, although $\frac{2}{3}$ may seem quite favourable for one specimen, in another $\frac{3}{4}$ of the amount of liquor potassæ which would have been requisite for full neutralization before boiling appears to produce more speedy results. Such or analogous differences may have to be ascertained also in regard to the urine of different individuals.

heated and drawn out to a narrow extremity, after which the urine is gently boiled for about two minutes over a flame, great care being taken to avoid any waste of the fluid by spurting. During the continuance of ebullition the extremity of the vessel is hermetically sealed. Some little practice is required to do this properly—that is, on the one hand to seal the vessel whilst there is a gentle outpouring of steam, and, on the other hand, to do it in such a way that there is no inbending of glass at the sealed extremity. Even a small amount of such inbending is very apt to lead to a minute crack at the next stage. After allowing an interval of $\frac{3}{4}$ of a minute for the sealed tip to cool a little, the vessel is inverted, and in this position is at once immersed in a can of boiling water prepared, and ready to hand, for this purpose. Here the experimental vessel is left for 8 minutes or more.

Three purposes are served by this double process of heating. In the first place, it simplifies the experimental conditions to get rid of the air by boiling; secondly, the speedy closure of the vessel and the prolongation of the heating in a can of boiling water reduces the loss of fluid by boiling to a minimum; and thirdly, and principally, the inversion of the experimental vessel during the second period of heating brings those upper portions of the internal surface, as well as the outer surface, of the liquor-potassæ tube (which, during the boiling over the flame, may only have come into contact with steam at 212° F.), into continuous contact with the heated fluid itself*.

After the urine in the boiled retort has become cool, the liquor potassæ is allowed to mix therewith. This is easily brought about by shaking the retort or flask so as to jerk the bent capillary extremity of the liquor-potassæ tube against its internal surface. The neck of the previously closed tube is thus broken off, and the liquor potassæ itself, owing to the comparative vacuum within the experimental vessel, is forced out and mingles with the sterilized acid urine.

If six or ten vessels have been prepared in this way charged with the same stock of urine, some one or two of them may be selected for "control" experiments. In these the liquor-potassæ tubes are not broken, whilst in all the others they are; so that when subsequently placed in the incubator together at a temperature

* The whole of the internal surface of the liquor-potassæ tube is similarly exposed to the influence of its heated and caustic fluid during these different modes of heating.

of 122° F., the two sets of retorts constitute crucial experiments capable of testing the influence of liquor potassæ upon the sterilized urine.

What I have found to happen almost uniformly in about two hundred of such experiments is this :—If suitable fluids are dealt with—that is, specimens of fresh urine whose acidity before boiling does not require less than 8 minims of liquor potassæ per ounce for neutralization, and which do not deposit phosphates on boiling—the urine in the control experiments remains clear and apparently unaltered for an indefinite time; whilst where the potash has been allowed to operate upon the sterilized fluid, it becomes turbid, lighter in colour, and swarms with organisms in from 18 to 36 hours, on an average. The period with different urines is sometimes less and sometimes more, though no great prolongation occurs except through some alteration having been brought about in the proper ratio which should exist between the acidity of the boiled fluid and the amount of liquor potassæ which is added thereto. Such delays in the occurrence of fermentation were common enough during my earlier trials with this method; but now that I have more carefully studied and ascertained some of their causes, I am generally able to obviate them and ensure the supervention of fermentation within two or three days*.

This fermentation of urine to which liquor potassæ is added after boiling, unquestionably takes place more readily in a flask plugged with cotton-wool than in a sealed retort from which air has been expelled by boiling. And that the slightly diminished readiness of the fluid to ferment in the airless retort is attributable to the absence of atmospheric oxygen, seems to be confirmed by other experiments now to be recorded, in which an increased readiness to change is exhibited by urine and liquor potassæ under the influence of nascent or less-diluted oxygen, liberated by electrolysis.

I have also in two experiments with closed flasks containing urine and ordinary atmospheric air† liberated the liquor potassæ after the flask and its contents had been boiled, with the effect of finding fermentation take place several hours earlier than it did

* In a few cases this has occurred even when the urine has been heated in the can for 1–2 hours. Thus, I have seen it happen three times where the urine has been boiled for one hour, and once where it has been boiled two hours. With potash added beforehand almost to neutralization, I have twice seen urine ferment even after three hours' boiling.

† The flasks having been hermetically sealed whilst the urine was cold.

in other companion retorts whose contents were similar, except for the fact that they contained no atmospheric air. The liberation of the liquor potassæ from the tube with a capillary neck can only be brought about with great difficulty in a retort containing air; and this was the reason of my giving up the conditions more favourable to the fermentation of the boiled urine, in order to avail myself of the facile and automatic emptying of the liquor-potassæ tube which takes place in the retort from which air has been expelled by boiling.

In a trial of the combined effects of oxygen and alkali upon urine whose specific gravity was 1028, and whose acidity was neutralized by 18 minims of liquor potassæ to the ounce, distinct turbidity of the fluid of the retort to which oxygen had been added made its appearance in thirteen hours; whilst in a companion vessel similarly treated, except for the absence of free oxygen and hydrogen, turbidity did not show itself till the expiration of the forty-first hour.

On another occasion, when experimenting with urine whose specific gravity was 1023 and whose acidity was neutralized by 5 minims of liquor potassæ to the ounce, I found that the fluid in two retorts into which liquor potassæ had been liberated, and also a quantity of oxygen and hydrogen, became distinctly turbid in five and seven hours respectively; whilst the fluids in companion vessels similarly treated, except for the absence of oxygen and hydrogen, did not show signs of turbidity before $22\frac{1}{2}$ hours. This result was very remarkable, since, under the combined influence of liquor potassæ, oxygen, and a temperature of 122° F., a specimen of boiled urine became turbid much more rapidly than a simple specimen of unboiled urine would have done, exposed to a temperature of 77°–86° F.

It seems quite useless for me, in the present state of inquiry in regard to these questions, to dwell upon the fact of the number of times I have produced this or other results, or to describe them in more detail. What I seek to do now is, by careful description of my methods, to enable others, who will exercise proper care, to obtain similar results. With this object in view, I shall, in the first place, refer to certain causes of failure, and to certain causes of variation in the time of supervention of fertility in sterilized urine under the influence of liquor potassæ, to which I have already drawn attention in a previous paper*, in order to show why

* Now deposited in the Archives of the Royal Society.

failure has as yet attended the efforts of others to reproduce these very delicate though crucial experiments.

At an early stage of this investigation experiments were made by me to test the relative effects of different amounts of liquor potassæ in such experiments as I have just described. I found that if only two or three drops of this fluid were added from a similar tube to a quantity of boiled urine when, in accordance with the directions previously given, it would have required 10, 12, or more minims, such a specimen of urine was never fertilized. This convinced me fertilization in the other cases was not due to the survival of germs either in the liquor potassæ or in the small amount of air within the liquor-potassæ tube, and consequently that the heat to which this had been submitted had been quite sufficient to sterilize its contents. One drop of this, as of any other fluid, if it really contained living germs, would always suffice to infect many ounces, a gallon or more of urine.

The same conclusion, viz. that the contents of the liquor-potassæ tube had been completely sterilized, was also forced upon me by the fact, which I frequently verified, that an excess of liquor potassæ to the extent of 1 or 2 minims beyond the proper proportion would also invariably cause the urine to remain sterile in these experiments with airless vessels—a result which would have been impossible if living germs had really been contained within the liquor-potassæ tubes. A slight excess of liquor potassæ was, in fact, soon found to be rather more inhibitory in dealing with airless flasks than it had been when experimenting with flasks whose necks were plugged with cotton-wool—as in those of my tentative first series, in which the fluids were, of course, exposed to the influence of atmospheric oxygen. It was in consequence of this, and because on trial I have found that a slight deficiency of liquor potassæ was comparatively harmless, that in the paper sent to the Royal Society last year, of which an abstract only has been published, I counselled the addition in the plugged-flask experiments of $\frac{7}{8}$ of the quantity of liquor potassæ which would have been needed for neutralization before boiling, and in those with closed airless vessels its addition to the extent of $\frac{6}{8}$ of such quantity.

In relation to the variable period of fertility, to which I also called attention in the paper above mentioned, as occurring in my earlier experiments, it may be well to quote the following remarks:—"This variability might, I think, be in a great measure

obviated in the future, first, by a more strict attention than I at first bestowed upon obtaining or providing for the precise degree of neutralization desired—secondly, by attention to a fact of the full significance of which I was not at first aware, viz. that the acidity of the urine in certain cases becomes notably diminished by boiling. This diminution in acidity seems invariably to occur where acid phosphates are precipitated by boiling. The result is, that, wherever this occurs, the liquor potassæ is liable to be added to the boiled urine in a harmful excess, since the quantity supposed to have been required, and enclosed within the liquor-potassæ tube, was calculated upon the degree of acidity of the fluid before it had been lessened by boiling. In cases of prolonged heating this diminution of acidity may have been very appreciable. In a specimen of phosphatic urine whose acidity was equal to 5½ minims of liquor potassæ to the fluid-ounce, I found the acidity only equivalent to 4 minims to the ounce after the urine had been boiled for only 2 minutes. In all cases, therefore, in which, after a preliminary trial, phosphates are found to be deposited by boiling the urine, it would be proper to estimate the acidity with a specimen of the fluid which had already been boiled for the period determined upon as that to be employed in the experiments about to be made. This is a precaution which should in future never be omitted"*. . . . "It must not be forgotten also that in boiling the measured quantity of urine in the retort before its neck is sealed, any excessive spurting away of fluid may cause an alteration in the proper ratio between urine and liquor potassæ."

Another cause of variation in the time of fermentation in specimens of the same set is the different rate of boiling to which the fluids have been subjected during the first period—that is, whilst the fluid is being boiled over the flame. Rapid boiling in a retort or flask with a capillary extremity will very frequently cause the temperature to rise as much as 3½° C. (nearly 7° F.) above the boiling-point, as I first ascertained in 1873†. Accidental variations in the rate of boiling, causing the temperature to be raised to different points, may thus affect successive fluids of the same stock differently. This, indeed, is another reason why it is desirable to curtail the period of boiling over the flame and

* I would rather say now that it is better not to use such a fluid at all in these particular experiments.

† See 'Nature,' vol. ii. (1870) p. 227.

finish the heating process after the experimental vessel has been hermetically sealed.

Since the first announcement of my new experiments, and before the publication in detail of my method, two English investigators have attempted to repeat them. Their method of procedure, however, has been inaccurate and probably vitiated by the three causes of error above mentioned as having been pointed out in my original paper now in the possession of the Royal Society; it was certainly, according to their own statements, vitiated by two of them, as I will now proceed to show.

After referring to what appeared to him to be two sources of fallacy in my mode of conducting these experiments (to the mention and consideration of which I shall presently return), Dr. William Roberts * says he determined to repeat them, but taking care to avoid these alleged "defects." He proceeded as follows:—"A flask with a longish neck was charged with an ounce of normal acid urine. The due quantity of liquor potassæ *requisite to exactly neutralize this* (as ascertained by previous trials) was enclosed in a sealed glass tube drawn to a capillary portion at one end. The tube was then heated in oil up to 280° F., and maintained at that temperature for fifteen minutes. The tube was then introduced into the body of the flask. The neck of the flask was next drawn to a narrow orifice; then *the urine was boiled for five minutes, and the orifice sealed in ebullition.*" Now, having regard to the two passages which I have italicized, it will be seen that Dr. Roberts's supposed repetition of my experiment was no repetition at all; that is, he followed the very method most calculated to ensure failure, and which even what was said in my published "Abstract" should have warned him against adopting †. As I shall presently explain, potash sufficient to render the fluids distinctly alkaline was added; and this, together with the boiling for five minutes before the vessel was sealed, was doubtless the cause of Dr. Roberts's failure.

The same Number of the 'Proceedings of the Royal Society' contains a "Note" by Professor Tyndall, in which he likewise announces the fact that he has failed to reproduce my results. His mode of repeating the experiment was also erroneous, at all events, in those of his trials in which he makes any mention of the

* 'Proceedings of the Royal Society,' No. 176, vol. xxv. p. 455.

† See 'Proceedings of the Royal Society,' vol. xxv. p. 503.

method employed. All that he says on this essential point is as follows:—"In some of the experiments the procedure described by Dr. Roberts was accurately pursued, save in one particular. . . . His potash-tubes, however, were exposed to a temperature of 280° Fahr., while mine were subjected to a temperature of 220° only." These experiments of Professor Tyndall, therefore, like those of Dr. Roberts, will only tend to confirm my statement that the addition of potash in excess leads to negative results. They have no other bearing upon my experiments, and they consequently afford no evidence whatever as to the efficacy of the two precautions, the necessity for which they were destined to illusstrate, and to whose discussion I shall presently return.

One other experimenter has also questioned my results, though I cannot say that he has repeated my experiments. This is none other than the illustrious French chemist himself, M. Pasteur. In reply to a brief note of mine on the subject of these experiments, which was sent to the French Academy, and in which my exact method of procedure was not described, M. Pasteur accepted the fact as true, but denied the interpretation. He, however, instead of adding to the sterilized urine a quantity of liquor potassæ almost sufficient to neutralize it, added, as he says, solid potash which had been heated to redness, or a solution of potash heated to 230° F. (110° C.), and this in quantity sufficient to render the urine "alkaline." The result was (as I should have expected), that the urine so treated remained barren. This barrenness I attribute to the fact that the potash had been added in excess; M. Pasteur, on the other hand, attributed it to the higher temperature to which the potash had been heated, and proclaimed his modified experiment as a triumphant vindication of the truth of his previous theory. And yet it was not even this. His previous position was, that in *neutral or slightly alkaline* organic liquids certain germs were not killed at a temperature of 100° C. which were killed at 110° C. Here, however, was liquor potassæ, a *very strongly alkaline fluid, so caustic as to be capable of dissolving protoplasm even when cold*; and M. Pasteur would have us believe that germs can, when immersed in it, resist a temperature of 100° C.—because he thought they did so in the very much weaker fluid. Much evidence would be needed to bring conviction to the minds of physiologists on this point; and as yet none has been offered.

At present, therefore, my experiments have not been repeated

by either of these investigators. The trials they have made most closely resemble those experiments of mine which illustrate the effects of adding liquor potassæ in excess; and the results they have obtained tend to confirm mine, and illustrate the restrictive influence of even a slight excess of this agent.

I now turn to the subject of Dr. Roberts's criticism of my method, because in pointing out the untenability of his positions I shall be able to throw some light upon the subject generally.

Two objections have been raised by him to the mode in which I conducted my experiments, seemingly on the ground that in the five experiments of this order which he had previously made, two procedures were adopted which I did not imitate. Dr. Roberts thinks that I ought (1) to have superheated the liquor-potassæ tubes; and he thinks (2) that I ought to have allowed an interval of some days to elapse before breaking them and permitting the potash to mix with the boiled urine. Both these objections are indorsed by Professor Tyndall; and, as we have seen, an objection very similar to the first of them had previously been urged by M. Pasteur; they require, therefore, to be critically examined*.

(1) *Is it necessary, or does any difference result from superheat-heating the potash-tubes?*—To the first part of this question I had, previously to the date of my first communication on this subject, given an answer in the negative, and that for the following reasons:—

(*a*) Quite early in this investigation I made comparative experiments to test whether any or what influence over the result would be produced by prolonging the period for which the closed liquor-potassæ tubes were heated; so that Dr. Roberts is in error in supposing that they had been raised only for "an inconsiderable period to the heat of boiling water." In the majority of the experiments they were heated to this extent for over twenty minutes; and in several of them they were boiled for one and two hours. It was only when I found that this prolongation of the boiling of the liquor-potassæ tubes did not in the least affect the result that I contented myself with the shorter period of twenty minutes.

* M. Pasteur urged the superheating of the potash-tubes on the ground, as above pointed out, that a temperature of 110° C. was needed to ensure the death of germs even in a strong solution of caustic potash. Dr. Roberts does not venture so far as this. He considers the high temperature needful in order to ensure sterilization of the air within the liquor-potassæ tubes.

(*b*) But I had, and I made known even in the abstract of my paper, a convincing proof that this comparatively short period of exposure to the temperatnre of boiling water was in fact sufficient to sterilize the contents of the liquor-potassæ tubes—as well the liquor potassæ as the small quantity of air which they contained*. This was to be found in the fact that one of these tubes charged with a very small amount of potash, or one charged with a slight excess, never, when broken, caused the urine to ferment, even though it had only been heated to 100° C. for twenty minutes. This seemed to me, and still seems, a convincing proof that no living germs existed within the tubes.

But when such prominence was given to this part of the question by M. Pasteur—when, accepting the crucial nature of the experiment, he challenged me to produce the results which I had announced with sterile urine and a solution of potash, " à la seule condition que cette solution sera portée préalablement à 100 degrés pendant vingt minutes, ou à 130 degrés pendant cinq minutes," I was very glad to meet his views and perform some experiments under these conditions prescribed by M. Pasteur †.

The results even with liquor-potassæ tubes heated to 110° C. for *twenty hours* were in no way different from those previously procured with tubes heated only for a short time to 100° C.‡ After this I also repeated my experiments with liquor-potassæ tubes which had been heated in oil to 140°–150° C. (284°–302° F.) for one hour §. The results were similar. In fourteen experiments with a urine of 1020 specific gravity, whose acidity was equivalent to 10 minims of liquor potassæ per ounce, and which did not deposit phosphates when boiling or, except to the slightest extent, after the addition of the potash, fermentation took place in all.

* See 'Compt. Rend.' Jan. 22, 1877.

† The reality of my results M. Pasteur admits. Thus, in the 'Comptes Rendus,' July 17, 1876, tome lxxxiii. p. 178, he says, "Je m'empresse de déclarer que les expériences de M. le Dr. Bastian sont, en effet, très-exactes ; elles donnent le plus souvent les résultats qu'il indique." The only question between M. Pasteur and myself is as to the interpretation of results now common to both. His interpretation (Comp. Rend. 29 Jan. 1877, tom. lxxxiv. p. 206) is that germs are added with the liquor potassæ.

‡ See 'Comptes Rendus,' Feb. 12 (1877), tome lxxxiv. p. 306.

§ A most troublesome process and method, because of the subsequent difficulty in cleaning the potash-tubes.

This first criticism is, therefore, quite invalid; it was directed towards a requirement which I had borne fully in mind from the commencement of these experiments, and had fully met.

(2) *Is the method of the "control" experiment legitimate in such investigations? or must we in each case allow an interval of some days to elapse before breaking the liquor-potassæ tubes?*—Dr. Roberts says *:—"It is not sufficient to rely in such a case on a control-flask or retort. Each flask or retort should have its own individual sterility tested, because it is practically impossible to apply the heat exactly in the same degree in any two cases." To this I demur, and maintain that where the results are checked and verified by a large number of trials, the method of the control experiment is a more accurate and scientific method than that to which he and, following him, Professor Tyndall had resort. This position is based upon the following considerations.

First, it may be premised that the method of the "control" experiment has hitherto been habitually practised by many eminent investigators, and that it has always been thoroughly relied upon in cumulating evidence which was believed to be in favour of the "germ theory."

Secondly, Dr. Roberts's objection to its use in these experiments carries all the less weight with it because, as I have many times ascertained both before and since the publication of my first results, an exposure of two or three minutes' duration to the temperature of 212° Fahr. always suffices to sterilize a urine of average acidity, whatever the incubating temperature to which it may subsequently be exposed. Moreover, previous to the announcement of my results the undeviating verdict of other experimenters with urine—the verdict of Pasteur, of Sanderson, of Lister, of Tyndall, and even of Roberts himself—had been that after boiling it for two or three minutes, urine kept in a warm place, and free from extraneous contamination, always remained pure †. Such an amount of heat had invariably been found sufficient to sterilize it. Why, therefore, when dealing with such a fluid, could it be necessary to wait in each case before the liquor-potassæ tubes were broken?

In further support of the efficacy and trustworthy nature of the method adopted by me, I may state that I have several times repeated it in this manner:—Selecting any one at random from a

* 'Proceed. of Royal Society,' No. 176, vol. xxv. p. 455, note.

† See quotations to this effect at p. 2.

batch of 6–10 retorts or flasks whose contents had been boiled over the flame for 2″ and which were sealed during ebullition, I have correctly predetermined that this particular fluid should remain sterile by simply omitting to break its associated liquor-potassæ tube, and that the others should ferment even after boiling them for an additional period four times as long—this result being induced simply by breaking their properly charged and superheated liquor-potassæ tubes. It seems, therefore, superfluous to urge that when such experiments are multiplied with essentially similar results, as they have been, they afford evidence of the most crucial and unmistakable character.

Dr. Roberts, however, impeaches this well-tried experimental "method of difference;" and Professor Tyndall countenances the impeachment. Let us see what kind of method they would put in its place.

Dr. Roberts thinks it absolutely necessary to wait several days, or even a fortnight, in order to make perfectly sure that each individual fluid is sterilized before adding the superheated potash thereto. Having shown that the grounds on which he rejects the evidence of the control experiment are peculiarly weak in regard to a fluid so easily sterilized as urine, I will now endeavour to show that the alternative procedure which he recommends to replace this legitimate method is, on the contrary, open to the most serious objections. Dr. Roberts, like Professor Tyndall, is never unmindful of "the plain indications of the germ theory;" and though he does not persistently ignore, still he is not always equally mindful of the plain indications of the opposite theory. From the point of view of the germ theory, it is true, there is not so much to be said against this delay in the liberation of the liquor potassæ; but from the point of view of the opposite theory, the serious question arises as to whether any or what chemical changes would take place in the experimental fluids during this period of probation. Other questions, as will be seen, have also to be considered in regard to their method.

It is almost difficult to believe that Dr. Roberts could have been speaking seriously when he said* that from the point of view of the spontaneous-generation theory "there was no reason why the alkali should not have been equally effective in promoting germination, whether added before or after the short preliminary

* Phil. Trans. vol. clxiv. (1874) pt. 2, p. 474

boiling,"—when under the word "after" was included a period of fourteen days' exposure "in a warm place."

The validity or degree of cogency of this statement may, perhaps, be best appreciated by translating it into a symbolic formula :—

Let A represent ... The experimental fluid (urine).
,, x ,, ... The total chemical changes induced by boiling it in its acid state.
,, x' ,, ... The total chemical changes induced by boiling it after neutralization by potash.
,, y ,, ... The chemical changes which the boiled acid fluid may have undergone during the period of probation.
,, z ,, ... The influence of potash upon this boiled acid fluid after the probation-period.

The statement of Dr. Roberts is, therefore, tantamount to this :—*Because* $A+x'$ *leads to fermentation, there is no reason why* $(A+x+y)z$ *should not lead to fermentation.*

That this is no mere fanciful exaggeration of the differences between experimental conditions which in their totality are assumed to be similar, I will now endeavour briefly to point out.

(x and x') In regard to the relative effects of boiling an organic mixture in an acid and in a neutralized condition, I have elsewhere made the following remarks* :—"When two portions of a solution containing organic matter, the one neutral and the other acid, have been raised to a temperature of 212° F., the organic matter of the one has been injured only by the mere action of heat; whilst that of the other solution, which has been acidified, has not only had to submit to the deleterious influence of the high temperature, but also to the increased activity of the acid at this temperature. The result would be, that the amount of difference existing between the two solutions before they had been heated† would be found more or less increased after they had been exposed to the high temperature, in direct proportion to the increase in intensity of the action of the acid produced by such high temperature. What we know concerning the precipitation of albumen in urine is quite in harmony with this view. When albumen is present, and the fluid has an alkaline reaction, mere boiling does not cause its precipitation—though, if the reaction is acid, the

* 'Beginnings of Life,' 1872, vol. i. p. 372.

† See p. 13 of this memoir.

albumen present would be precipitated when, or even before, the temperature of the fluid was raised to the boiling-point. Or a similar result might have been induced by the addition of a small quantity of acid to a portion of a neutral or alkaline albuminous urine which has just been boiled without a precipitation of the albumen having been brought about. Thus the addition or presence of a small quantity of acid, in conjunction with an elevated temperature, is seen to be capable of bringing about results which cannot be produced by the mere elevated temperature alone." Therefore it happens that the difference naturally existing between the fermentability of the same fluid in a neutral and in its acid condition is often notably intensified after boiling*.

This difference of effect produced by boiling acid and faintly alkaline fluids respectively may, however, be only in part due to the cause above indicated. Another factor comes into play which may be even more influential; and that is, that the boiling-point of the two liquids is different. Thus I find that neutralized urine not only boils with more frothing, but also at a decidedly lower temperature, than some of the same fluid in its acid state. The neutral fluid will boil in a retort with a capillary extremity at 99·8° C.; and it *must* be boiled gently on account of the frothing and tendency to spurt over; but some of the same fluid in its acid state will reach a temperature of 103° or 103½° C. easily. In the same vessel distilled water briskly boiled reached a temperature of 103° C.; so that the boiling-point of the neutral infusion is, by reason of its neutralization, decidedly lowered †.

Such a difference in temperature, therefore, may produce a very marked difference in the total effects of the boiling process in the neutral and in the acid infusions respectively; and these differences will be more marked in some cases than in others, according to the briskness of the ebullition of the acid fluid. I have seen this point well exemplified in more than one instance of late when dealing with a urine of rather low acidity from which phosphates

* See 'The Beginnings of Life,' vol. i. pp. 394–396.

† These comparative trials were made with the same quantities of the different fluids placed in a rather wide-mouthed retort, with a small maximum-thermometer whose bulb was kept away from contact with the glass. To the neck of the retort was fitted in each case, by means of a piece of india-rubber tubing, the same drawn-out neck. The comparison in the different trials was therefore thoroughly accurate.

were deposited. If the fluid is boiled slowly, the cloudiness thus occasioned may be slight; whilst in another vessel, whose contents are more briskly boiled, the deposition is decidedly greater. Two such fluids, ostensibly treated in the same way (that is, reported as having been boiled for the same period), have really been treated quite differently; and they will probably show it by the different periods at which fermentation supervenes; only, contrary to what usually occurs, in this particular case the one which has been boiled most briskly and whose temperature has been raised to a higher degree, will be the first to undergo change.

(*y*) Now comes the question whether a boiled solution of organic matter contained in a hermetically sealed vessel and kept in a "warm place" is in a condition of unstable or of stable equilibrium. Does it or does it not undergo modification? Have we, after an interval of fourteen days, to do with precisely the same fluid as before, or with a fluid which is more or less different?

Dr. Roberts argues as though it underwent no change; I, however, have ascertained that urine does undergo most notable and definite changes; and in 1872 I brought forward some facts tending to show that other organic fluids gradually lapsed into a more stable condition under the circumstances above indicated*.

As it is the behaviour of urine which now specially interests us, we had better for the present confine our attention to it. I will therefore first refer to the changes which its principal constituent, urea, is known to undergo when operated upon by heat of different degrees of intensity.

It has been long ascertained that urea is decomposed variously by different degrees of heat. Thus, turning to the fifth edition of Fownes's 'Manual of Chemistry,' published in 1854, I find at p. 537 the following statement concerning urea:—"When heated it melts, and at a higher temperature decomposes with evolution of ammonia and cyanate of ammonia; cyanuric acid remains, which bears a much greater heat without change. *The solution of urea* is neutral to test-paper; it is not decomposed in the cold by alkalies or by hydrate of lime, but *at a boiling-heat emits ammonia and forms a carbonate of the base.*" On the next page it is stated that "*if urine in a recent state be long boiled, it gives off ammonia and carbonic acid from the same source.*"

* 'Modes of Origin of Lowest Organisms,' 1871, pp. 73 and 78, notes * & †, and Expt. No. xxxiii.

This latter statement would not give one much reason to believe that the conversion of urea into carbonate of ammonia took place very readily in urine under the mere influence of warmth. And this impression was strengthened in my mind by the fact that no allusion was made to such a decomposition by M. Pasteur. I was, indeed, impressed by opposite statements made by him. Referring to a little chaplet-like organism common in unboiled fermenting urine he said *:—"Je suis très-porté à croire que cette production constitue un ferment organisé, et qu'il n'y a jamais transformation de l'urée en carbonate d'ammoniaque, sans la présence et le développement de ce petit végétal. Cependant mes expériences sur ce point n'étant pas encore achevées, je dois mettre quelque réserve dans mon opinion." On the same page M. Pasteur says that if urine is boiled for two or three minutes in a vessel to which only calcined air is admitted before it is hermetically sealed, and if it is thereafter exposed in a stove to the influence of a temperature of 25° to 30° C. (77°–86° Fahr.), "il peut y séjourner indéfiniment, sans éprouver d'autre altération qu'une oxydation lente de la matière albumineuse de l'urine * * * la limpidité de l'urine reste parfaite, même après dix-huit mois, et il n'y apparaît pas la plus petite production animale ou végétale; *elle conserve également son acidité* et son odeur première."

Under the influence of these statements I was at first not apprehensive that the urea of the urine became sensibly converted into carbonate of ammonia during a short ebullition, or that any change of the same kind went on afterwards whilst it was in the incubator. My attention, however, was specially directed to this subject by a statement made by M. Pasteur in the early part of the present year. He said†:—"It is not useless to say here that, contrary to what is generally admitted, urea in aqueous solution or in urine is decomposed at 100° C., and even at temperatures much lower. The product of decomposition is carbonate of ammonia." This induced me to give special attention to this subject; and the result has been the full confirmation of Pasteur's recent statement, in opposition to his earlier impressions and statements.

If a piece of moistened red litmus paper is exposed to the steam coming through the capillary orifice of a retort in which ordinary acid urine is being boiled, this paper is for a time rendered faintly

* *Loc. cit.* p. 52. † Compt. Rend. Jan. 8, 1877, tom. lxxxiv. p. 64.

blue, showing that some ammonia is being given off sufficient to make the steam from acid urine faintly alkaline.

I then proceeded to make some quantitative determinations as to the amount of diminution of acidity occasioned by boiling urine both in an open vessel and, under pressure, in a closed vessel—also as to the subsequent rate of change when urine was kept at different incubating-temperatures. Accidents happened to some members of the first series which I prepared with the view of throwing light upon this subject. The results ascertained from three of the vessels which escaped were, however, sufficiently significant to show the importance of the inquiry:—

	Treatment.	*Result.*
Urine whose acidity was exactly neutralized by viii½ minims of liquor potassæ to the fluid-ounce.	1. One fluid-ounce of the acid urine was boiled in a retort with a capillary neck for 5″ over the flame pretty briskly, but without spurting-away of fluid.	1. Fluid found to have been diminished by ʒiij. Acidity of remainder neutralized by v½ minims of liquor potassæ.
	2. One fluid-ounce of same boiled gently over flame 2″, and in can of water, after sealing, for 18″.	2. Fluid diminished by ʒ¼. Acidity of remainder neutralized by vj minims of liquor potassæ.
	3. One fluid-ounce of same boiled gently over flame 2″, and in can of water, after sealing, for 8″. Then placed in incubator at 122° F. for 6 days.	3. Fluid diminished by ʒ¼. Acidity of remainder neutralized by iv minims of liquor potassæ.

These estimations, confirmed as they have been by others, soon let in a flood of light. The great diminution of acidity caused by brisk boiling in an open vessel with a capillary orifice was remarkable, and is doubtless principally attributable to the fact that under these conditions the temperature of the fluid is easily raised three or four degrees of the Centigrade scale above the boiling-point; the loss of acidity involved in the diminution of the fluid itself by the mere process of boiling, but without appreciable spurting, was probably small*. But when both these conditions are obviated as much as possible by gentle boiling over the flame for two minutes only, and by continuing the exposure to heat, after the vessel has been sealed, in a can of boiling water at a definite temperature of 212° F., the total period of heating may be four times as long without causing as much diminution of acidity as was found in the five minutes of brisk boiling over the flame. Then, again, it appears from the third experiment that the trans-

* See a communication by Dr. Frankland, Proceed. of Royal Society, No. 178 (1877), vol. xxv. p. 542.

formation of urea into carbonate of ammonia goes on at a very appreciable rate whilst the urine is exposed in the incubator to a temperature of 122° F. (50° C.).

Experiments made with another specimen of urine of very nearly the same acidity yielded the following results. Exactly one fluid-ounce was used, as before, in each experiment.

	Treatment.	*Result.*
Urine whose acidity was exactly neutralized by ix minims of liquor potassæ to the fluid-ounce.	1. Boiled gently for 5″ over flame, without spurting.	1. Diminished by ʒi. Acidity = m. vj½ of liq. pot.
	2. Boiled for 2″ over flame, 8″ in can of water.	2. Diminished about ʒ¼. Acidity = m. vj of liq. pot.
	3. Boiled for 2″ over flame, 8″ in can. Left at 122° F. for 3 days.	3. Diminished by ʒ¼. Acidity = m. iv of liq. pot.
	4. Boiled for 2″ over flame, 18″ in can.	4. Diminished by ʒ¼. Acidity = m. iv½ liq. pot.
	5. Boiled for 2″ over flame, 38″ in can.	5. Diminished by ʒ¼. Acidity = m. iij liq. pot.

The urea in this specimen seemed to undergo change rather more rapidly than in the last, as a careful comparison of the figures will indicate. Experiments 2, 4, 5 also seemed to show that the change takes place most rapidly at first, and subsequently tends to diminish; thus in No. 2, after ten minutes' boiling over flame and in can, we get a diminution of acidity equivalent to m. iij of liquor potassæ; in No. 4, with an extra 10 minutes' boiling in the can the further diminution of acidity only equals m. i½ of liquor potassæ; whilst in No. 5, with a still further period of 20 minutes' boiling the additional diminution of acidity was also equivalent to m. i½ of liquor potassæ.

Other experiments were made to ascertain whether the change of urea into carbonate of ammonia would still go on at lower temperatures; and this time the urine was one of much higher acidity and specific gravity. Exactly one fluid-ounce was used, as before, in each experiment.

	Treatment.	*Results.*
Urine whose acidity was exactly neutralized by m. xxj of liquor potassæ to the fluid-ounce.	1. Boiled for 2″ over flame, 8″ in can.	1. Acidity = m. xviij of liq. pot.
	2. Boiled for 2″ over flame, 8″ in can. Left at 83° F. for 7 days.	2. Acidity = m. xvj of liq. pot.
	3. Boiled for 2″ over flame, 8″ in can. Left at 122° F. for 7 days.	3. Acidity = m. xiij of liq. pot.

From this it appears that the diminution of acidity goes on at

a very appreciable rate, even at the comparatively low temperature of 83° F.*

These experiments show the amount of change which goes on in one of the principal constituents of urine during the time that it is being boiled over the flame or in a closed vessel, and also during the probation-period to which it was subjected in the attempts made by Dr. Roberts and Professor Tyndall to improve upon my experiments. It is extremely unlikely that this is the only change which the constituents of urine undergo; but the aid of the chemist is needed to enlighten us further upon this subject.

I am strongly inclined to believe that urine, where it does not ferment soon after being placed in the incubator, gradually lapses (like other organic fluids when, under similar conditions, they remain sterile) into a more stable condition through the supervention of slow chemical changes. This opinion is based upon the fact that such specimens of urine are found to be notably less prone to undergo fermentation when the necks of the vessels are broken and the fluids are freely exposed to the atmosphere, than specimens otherwise similar which have been exposed to the air within a few hours after having been boiled to the same extent. Barren urine which has been many days exposed to a temperature of 122° F. will remain for days—or even for weeks, in many cases—in free communication with the air, without fermenting or showing any signs of change †. The urine is, indeed, reduced to a

* A few other estimations have been made of separate specimens of urine (though they were all of about the same acidity and specific gravity) after exposure for different periods to a temperature of 122° F. These I subjoin:—

1. Urine of sp. gr. 1020... Acidity per oz. = m. x.	Boiled 1″ over flame. ,, 10″ in can. At 122° F. for 11 days.	Acidity = m. v½ of liq. pot.
2. Urine sp. gr. 1020 ...... Acidity = m. x.	Boiled for 1″ over flame. At 122° F. for 20 days.	Acidity = m. iv liq. pot.
3. Urine sp. gr. 1022 ...... Acidity = m. x.	Boiled for 2″ over flame. At 122° F. for 40 days.	Acidity = m. ii½ liq. pot.
4. Urine sp. gr. 1020...... Acidity = m. x.	Boiled for 5″ over flame. At 122° F. for 6 days.	Acidity = m. iv. liq. pot.

† And when they do ferment, it is worthy of note that the organisms which appear (if not Moulds) are still Bacilli. Is it therefore that air-infection always yields this form because its germs are omnipresent, or because there is a correlation between the germs of any of these *variable* lowest organisms and many boiled fluids, of such a nature as commonly to lead to the development of Bacilli? The latter interpretation very much weakens the force of Prof. Cohn's inference from the fact of the frequency with which this form manifests itself in boiled and guarded fluids, viz. that its spores are able to survive boiling after desiccation (see p. 73). The former interpretation is so improbable that it has not yet been advanced.

condition of stability very similar to that which is possessed by a mere mineral solution of ammonic tartrate with sodic phosphate; that is to say, it invariably ferments when it is brought into contact with living Bacteria, but not under the influence of the finer atmospheric dust. It requires either living Bacteria (which would appear to be scarce in the atmosphere) or else the chance advent of some larger fragment of organic débris possibly containing living Bacteria-germs in its substance or on its surface *.

(*z*) Now we come to the third unknown term—that is, the nature of the influence of potash upon the boiled acid fluid after the probation-period. One thing seems quite clear, viz. that the fertilizing action of such an amount of liquor potassæ as it would be suitable to add to a stock of urine immediately after it has been boiled, does not repeat itself when this same amount of liquor potassæ is added to a similar stock of urine which has been kept in a warm place for a fortnight. One reason for this also is now quite plain. Whatever other changes the urine may have undergone during the interval, it is obvious that it would have diminished in acidity, and, consequently, that the liquor potassæ would have been added in excess—a condition which antecedent experience had shown to be invariably attended by negative results.

When therefore we find Dr. Roberts and Prof. Tyndall begin with putting too much liquor potassæ into their tubes, when they adopted a wasteful method of heating, which would most notably diminish the acidity of the urine, and when they finally kept it in a warm place for a fortnight, and thus still further diminished its acidity, it was only to be expected that such fluids should have invariably remained barren. The liquor potassæ was altogether wrongly proportioned to the acidity of the urine with which it was ultimately allowed to mingle. The fallacies besetting the supposed superior method to which they had resort, and the one-sidedness of the reasoning which dictated and permitted its adoption, thus become plain.

But even if this difficulty as to the adjustment of the proper quantity of liquor potassæ to be added to a measured stock of urine of known acidity, after a probation-period of so many days at a given temperature, and after a given period of exposure to a

* Proceed. of the Royal Soc. 1873 (No. 145), vol. xxi. p. 325.

temperature of 212° F. could be got over—if we could approximately calculate the degree of acidity of the fluid after exposure to these conditions—the question would still remain whether the urine had not altered in other important ways during the probation-period. The increased stability of the fluid previously referred to may not depend alone upon the conversion of some of its urea into carbonate of ammonia, but in part upon other unknown concurrent changes. So that even if we could add the potash (through previous calculation) in suitable quantity, it would not at all follow that it must necessarily exert so ready an influence upon this more stable fluid as it does upon urine just after it has been boiled. Will future careful experiments tell us something in regard to this part of the subject?

The question thus stated I have made some attempts to answer; that is, I have in part studied the effect of adding a quantity of liquor potassæ to a measured amount of sterilized urine of known initial acidity, when the actual amount to be added is based upon the consideration that the urine will have been heated to 212° F. for a prearranged time, and subsequently kept in an incubator at a given temperature for a certain number of days.

The results as yet have not been very satisfactory, since in eighteen consecutive trials I only succeeded in inducing fermentation ten times.

The successes have been in cases in which after boiling in the usual manner over the flame and in the can of boiling water, the experimental vessel has been kept for 6–8 days at temperatures between 70° and 80° F. before the liquor-potassæ tube has been broken, and when this tube has contained an amount of superheated potash equivalent to about one third of what would have been required to neutralize the acidity of the urine employed previous to boiling.

The more the interval is prolonged, or the higher the incubating temperature during this interval, the less seems to be the probability that fermentation can be induced. These, however, are points which I intend to study further; so that I will not go into any minute details at present.

It is only to be expected that a large number of failures should be encountered at first in such experiments—where there are so many changes to be taken into consideration, and where much still remains to be learned. Even if a fairly accurate calculation could be made as to the amount of alteration of the aci-

dity which will be brought about in the stock of urine by exposure to the temperature of 212° F. for a definite time and to that of the incubator for a given number of days (though different urines vary somewhat in their rate of change), there is the difficulty before alluded to, that the urine in this altered state is probably less apt to be acted upon favourably by potash in any proportion. Again, the most suitable proportion of potash to urine where the latter is in this condition may not be similar to that for recently boiled urine; and the question as to what proportion might be more suitable could only be determined with difficulty and after numerous merely tentative trials.

V. *Interpretation of Experiments with Urine and Liquor Potassæ.*

The fermentability of an unboiled acid organic solution is, as I have previously pointed out, lower in point of energy than that of an otherwise similar solution which has been rendered neutral or faintly alkaline*. This is an easily verifiable fact.

It was first pointed out by Pasteur that the same kind of difference was often encountered on the part of boiled infusions—that is to say, that an acid infusion which had been boiled would have its fermentability extinguished, though an otherwise similar neutralized infusion would ferment even after it had been boiled.

The higher tendency to ferment in the unboiled neutral infusion makes it not difficult to understand, and might have prepared us for Pasteur's announcement that this tendency is not extinguished by the same degree of heat as that which suffices to arrest fermentation in an otherwise similar acid infusion.

So far there is no room for dispute: I have mentioned only simple facts which any careful experimenter can easily verify.

But when we come to the question of the interpretation of the facts, difficulties arise. Pasteur, believing that fermentations are chemical processes only capable of being initiated by living units (and in the cases to which we are referring by units which are independent living organisms), declares that the different behaviour on the part of these boiled infusions is due to the fact that all ferment-organisms and their germs are killed in the boiled acid fluids, whilst they or their germs are able to survive in the boiled neutral fluids. No other interpretation seemed to him compatible with the truth of the "germ theory." Yet it should

* See p. 13.

be observed that this interpretation renders no explanation of the initial higher fermentability of the unheated neutral infusion.

It was to test the validity of this partial interpretation of the facts that my experiments were undertaken. If M. Pasteur's views were correct, the addition of no quantity of sterilized potash *after* the acid fluid had been boiled (and therefore also sterilized) should suffice to induce fermentation and the appearance of organisms. But, as we have seen, such results do follow. What explanation, then, can be given of these experiments? There is only one which is at all compatible with the above-mentioned view of M. Pasteur; and this shall be first referred to.

1. *The Fertilizing Agent contains living Germs.*—As I have already stated, this was very soon affirmed in a positive manner, by more than one experimenter, to be the explanation of my results.

In previous experiments recorded by other investigators in which barren fluids had been fertilized by the addition of fresh matter from without, such matter, being unheated, had always been assumed to produce this effect by reason of its containing living germs*. The explanation of my experiments being, therefore, facile and ready to hand, they were on this account speedily condemned, both before the French Academy and the Royal Society of London. Yet this particular interpretation had been fully considered, and its disproof had been set forth, when my results were first announced†.

It had been proved that neither the liquor potassæ nor the air within the little tube heated to 100° C. acts merely as a germ-containing medium, since the addition in the same manner of only one or two drops or of a slight excess of potash did not suffice to contaminate several ounces of boiled urine. But if the action of the contents of the liquor-potassæ tubes had been due to their containing living germs, a single drop of liquor potassæ, together with the air from such a boiled tube, should have always sufficed rapidly to initiate fermentation even in a gallon or more of urine. The fact that it did not, proved conclusively that neither the liquor potassæ nor the air of the tube was the bearer of living germs.

* See Pasteur's chapter headed "*Ensemencement des poussières qui existent en suspension dans l'air, dans des liqueurs propres au développement des organismes inférieurs,*" Ann. de Chim. et de Phys. 1862, t. lxiv. p. 40; Burdon Sanderson in Brit. Med. Journ. Mar. 27, 1875, p. 403; and Tyndall in Phil. Trans. (1876), vol. clxvi. p. 47.

† Proceedings of Royal Soc., vol. xxv. 1876, p. 154.

But after the superheating of the potash-tubes to 284°–302° F. (140°–150° C.) for sixty minutes, and to 230° F. (110° C.) for twenty hours, as recorded in this paper p. 31, with the production of fertilization as before—so long as the potash is properly proportioned to the urine—more conviction may, perhaps, be brought to the minds of others as to the absence of living germs within the potash-tubes.

This facile explanation of my results has therefore been proved to be erroneous, and my fertilizing experiments have been conclusively shown to belong to a different order from those previously familiar to experimenters—in which the added matter had always been unheated*.

M. Pasteur's interpretation of the fertility of boiled neutral or faintly alkaline fluids has thus been fully disproved. It may, moreover, be further disproved by direct experiment, in the following manner. We may take some turbid urine having a neutral or faintly alkaline reaction in which both Bacteria and Bacilli are swarming and rapidly multiplying, and we may compare the relative effects of heating these organisms with their reproductive particles to 212° F. in a neutral and in an acid medium respectively. Three series of experiments are needed:—

1. *Ferment-organisms heated to 212° F. in an Acid Fluid.*

Add one minim of the faintly alkaline turbid fluid containing ferment-organisms and their germs to one ounce of urine whose acidity is more than equivalent to ♏ x of liquor potassæ.

Boil 2″ over the flame, seal, and then 8″ in boiling water with the flask or retort in an inverted position.

When cool place in incubator at 122° F.

Result.—No change in fluid.

2. *Ferment-organisms heated to 212° F. in a faintly Alkaline Fluid.*

Place one minim of the same faintly alkaline turbid fluid in a little tube, draw out its neck and seal.

Immerse this tube in a vessel containing one ounce of the same specimen of urine.

Boil 2″, seal, boil 8″ in same manner, and when the fluid is cool, break the tube so as to liberate organisms which have been heated in their own faintly alkaline medium.

Place in incubator with others at 122° F.

Result.—No change in fluid.

* This is now fully admitted by M. Pasteur. He no longer seeks to deny that, acting in accordance with the original terms of his challenge, I can get the results which he then defied me to produce (see Compt. Rend. July 23, 1877, tom. lxxxv. p. 178, where a totally different explanation of my experiments is brought forward). The reason why this was not brought out before the Commission of the French Academy, appointed to report upon the question, is

3. *Control Experiment.*

Boil an ounce of the same acid urine in a small flask whose neck is plugged with cotton-wool for 10″.

When fluid has cooled remove cotton plug for an instant, and add one minim of the same turbid fluid not previously heated. Quickly replace cotton plug and transfer to incubator at 122° F.

Result.—Well-marked turbidity and swarms of Bacilli in 18–24 hours.

Such experiments have invariably given the same results. Twelve trials were made with a urine of 1030 sp. gr., whose acidity was equal to 10 minims of liquor potassæ per ounce; and nine trials were made with a urine whose acidity equalled 25 minims per ounce, and whose sp. gr. was 1030.

These experiments are of much interest, because they show in a most decisive manner that the mere neutrality or slight alkalinity of the medium in which the ferment-organisms are heated is quite unable to preserve them from the destructive influence of a temperature of 100° C.* They show also that Bacilli, not previously boiled, develop and multiply with great freedom even in very highly acid urine. Other experiments have also shown that these organisms can develop in strongly alkaline urine (see p. 48). Both these latter facts will help to throw light upon subsequent interpretations.

Meanwhile the perfectly proved conclusion at which we have arrived is this:—*M. Pasteur's explanation of the fertility of neutral or faintly alkaline fluids is erroneous; if ferment-organisms and their germs are killed at* 100° C. *in acid fluids they are also killed in neutral fluids at* 100° C. The explanation of the fertility of these neutral fluids, therefore, after boiling, both in the hands of M. Pasteur and of other experimenters, still remains to be discovered.

The one fact, indeed, to be recognized is, that the addition of liquor potassæ in proper quantity to a suitable acid infusion either *before* or *after* boiling will, under the influence of certain

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fully set forth in 'Nature', Aug. 2, 1877, p. 276. It would appear that, subsequent to the date of his challenge, M. Pasteur must have discovered that his original explanation was erroneous, and that whilst acting in strict compliance with its terms the superheated liquor potassæ would induce fertility, as I had said. No declaration to this effect, however, was made in my presence to the Commission; nor did the Commission itself make any such announcement to me.—*Sept.* 24, 1877.

* Confirmatory of other experiments which I made in 1873 ('Proceed. of Royal Soc,' No. 145, vol. xxi. p. 325).

suitable experimental conditions, cause this fluid to ferment and swarm with organisms *, though when it is simply boiled in its acid state it may remain barren. The explanation which applies to one will doubtless apply to the other set of results. We have, in fact, to deal with only one question:—*Why does a certain quantity of potash added to an acid infusion endow it with a higher fermentability than it previously possessed?*

Of the two explanations of this fact which were said to be possible on p. 14, the first has been fully disproved, as I have above shown. The second now remains for our consideration.

2. *The Potash must exercise some Chemical or Physical Influence in initiating Fermentative Changes.*—In regard to this mode of action two possibilities present themselves, and two only. It must act either (*a*) by leading to the *de novo* formation of germs; or else (*b*) by *reviving* germs hitherto presumed to have been killed in boiled acid infusions.

(*a*) It is perfectly clear that, if M. Pasteur and others are right in supposing that all ferment-organisms and their germs are killed in boiled acid fluids, no other conclusion is now to be drawn except *that fermentation may be initiated in the absence of living organisms, and that in the course of the process specks of living matter appear* de novo *as insoluble products of the changing liquid.*

(*b*) But if he and others have not been right in supposing that ferment-organisms and their germs are killed in boiled acid liquids, no such conclusion can be drawn from these experiments, and another interpretation would present itself, viz. *that the fertilizing agent acts by reviving and favouring the vital manifestations of germs hitherto presumed to have been killed in the boiled acid fluid* †.

* The greater difficulty and delicacy of the treatment necessary when we seek to induce fermentation by adding the liquor potassæ *afterwards* is doubtless due to the fact that in this case the fluid has been boiled in its acid state. In this condition, as I have already pointed out (p. 35), the temperature of ebullition is higher; and therefore the destructive influence of boiling such a fluid would, even on this account alone, be greater than if the alkali had been added beforehand.

† M. Pasteur's present interpretation of my experiments practically amounts to an adoption of this position (Compt. Rend. July 23, 1877), though apparently he has not yet recognized that, if it proves to be true, it must be equally applicable to his own previous experiments with milk and neutralized yeast-water—in which the alkali was added before boiling. If any germs or chemical ferments can survive on the walls of the experimental vessel, they must be in a state in which they are not actually killed in acid fluids, since in my experiments the reversal of half-full flasks or retorts during the two methods of heat-

Before we can safely adopt the first two-sided alternative as the explanation of my results, we must be thoroughly assured that the second equally two-sided alternative is out of the question. It is thus only that we can advance towards the truth in this inquiry. The correct interpretation will be arrived at *per viam exclusionis.* It must, from the very nature of the inquiry, rest upon inference rather than demonstration.

Further light may subsequently be forthcoming in favour of or against the explanation (*b*), of a *survival* with *life-renewal* of germs; but at present it seems to me to stand in this way :—

For.	*Against.*
The difficulty in believing that living matter can really have originated *de novo* in these experiments.	1. The proved inhibitory effect in my experiments of even a slight excess of potash, though previously unheated ferment-organisms will multiply in a strongly alkaline urine (7 of urine to 1 part of liquor potassæ) when exposed to the same temperature of 122° F. 2. All the previous evidence which led to the generally accepted conclusion that ferment-organisms and their germs are killed in acid fluids at 100° C. 3. The absence of any independent reason for doubting the validity of this conclusion—other than that cited in the left-hand column.

So also may further light subsequently be forthcoming in favour of or against the explanation (*a*), of the *death* and *de novo production* of germs in my experiments; but at present the principal considerations for and against this view appear to be as follows :—

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ing, would bring the whole inner surface into contact with the heated acid fluid. This could not be well done in M. Pasteur's more complicated apparatus; and, as I have already pointed out (p. 20, note *), there has been another important difference in our mode of procedure. Hitherto our standard of *neutrality* has been different; and it seems possible that the "neutrality" to which M. Pasteur reduced his fluid even *after* boiling (by means of potash) may have been for me a condition of "acidity" equivalent to about 7 minims of liquor potassæ per ounce. Again, in the experiments which I made with Prof. Burdon Sanderson ('Nature,' Jan. 9, 1873, vol. vii. p. 180), the superheating of the vessels was found to have no influence whatever over the results. In view of these complications some careful work will be required before I can speak further in regard to this last interpretation by M. Pasteur.—*Sept.* 24, 1877.

For.	*Against.*
1. All certain knowledge, based upon direct experiment, tends to show that no form of living matter can, in the *moist state*, resist an exposure even for one minute to a temperature of 212° F. (100°C.).	1. The *possibility* that some germs of ferment-organisms can survive long periods of desiccation, and that in this condition they are not killed by a brief exposure in fluids or vapour to a temperature of 212° F.
2. The appearance of ferment-organisms in suitable fluids within closed vessels which have been heated for periods ranging from 5 minutes to 8 hours to a temperature of 212° F.	2. The *possibility* that some germs of ferment-organisms can remain for 2, 4, 6, or even 8 hours either in fluids at 212° F. or in a medium saturated with vapour at 212° F., and yet not be rendered moist and killed.
3. The well-grounded belief that a *de novo* origin of living matter must have occurred in at least one period of the earth's history, and the absence of any sufficient reason for now questioning the continuity and potency of natural phenomena.	3. The *possibility* that natural conditions no longer permit the *de novo* formation of living matter either in experimental vessels or elsewhere —though this is a view supported by no independent evidence.
4. The consideration that if any such new birth now occurs, we might expect that it would be by the growth of invisible into visible particles; and that this is the ordinary mode of appearance of such organisms as are found in the boiled fluids within sealed vessels—that is, of ferment-organisms.	4. The *possibility* that the spontaneous origin of ferment-organisms will be disproved, simply because it is now admitted that the doctrine of "spontaneous génération" has been disproved in regard to higher organisms to which it was erroneously applied by our predecessors.

It seems to me that the facts and considerations of the left-hand column, to say the least, carry most weight with them, and that the exclusive doctrine of Biogenesis is compelled to assume a rather desperately defensive attitude.

Further evidence will be brought forward in the next and succeeding sections of this communication in regard to the general question; meanwhile it is evident that by my experiments with urine and potash, in addition to the disproof of a false hypothesis, I have unquestionably done one or other of two things: either (*a*) I have proved that living matter may be now evolved *de novo*, or (*b*) I have succeeded in bringing back to life germs which hitherto were so powerless and latent as to have been regarded by other experimenters as hopelessly dead. Even the latter is no mean result for the physician and the science of medicine, since, as I shall subsequently point out, the question of the truth or the reverse of

the "germ theory of disease," is thereby almost as powerfully influenced as if the former alternative had been established with complete certainty.

VI. *Experiments with Superheated Fluids.*

There can be no doubt that many organic fluids which have been heated only a few degrees above the boiling-point, and which are subsequently kept at a temperature of 86° F. (30° C.), will remain barren.

It is well known that neutral or faintly alkaline fluids will ferment after exposure to this higher temperature better than acid fluids. If, as I have endeavoured to prove, the former fluids have, owing to their constitution, a greater tendency to ferment than acid fluids, this is only what might have been expected. It stands to reason that if heat beyond a certain intensity tends to stifle the fermentable qualities of organic liquids, a lower degree of heat would extinguish these qualities in the less fermentable fluids than would suffice to annul them in the more fermentable fluids. If fermentability is a quality of organic fluids inseparable from, or solely dependent upon, the presence of certain living organisms, then the fact of fermentability persisting in an organic liquid after it had been heated to 105° C. (221° F.), would have been a proof that living organisms in some form could withstand the influence of such a temperature.

M. Pasteur found that specimens of milk and of sweetened yeast-water neutralized by carbonate of lime would in fact often ferment after they had been heated to 105° C.; and he very soon arrived at the conclusion that this was owing to the survival of Bacteria and Vibrio germs in these fluids. Finding, however, that in his hands even such fluids were invariably sterilized after they had been exposed for a few minutes to a temperature of 110° C. (230° F.), M. Pasteur proclaimed that such a degree of heat was certainly destructive of all germs in fluids —even of those above mentioned which, as he thought, most stubbornly resisted the destructive influence of heat.

The experiments already recorded have shown that Pasteur's explanation of the cause of the fermentation of the neutral fluids after boiling and after heating them to 105° C., is without sufficient foundation in fact—that it is, in short, directly negatived by strict crucial experiments.

I now have to bring forward additional evidence tending to

show that the induction of this same distinguished investigator as to the invariable barrenness of neutral liquids after they have been heated to 110° C., is also one which is overthrown by a wider circle of facts. By having resort to a simple physical agency (viz. a higher incubating-temperature than that which M. Pasteur formerly made use of), it can be easily shown that many properly prepared fluids may be made to ferment after they have been exposed even to 110° C. and upwards.

This final evidence is, of course, not strictly needed for the overthrow of the foundations on which M. Pasteur based his germ theory, what has already been brought forward concerning the fertility of boiled acid fluids, and the cause of the fertility of boiled neutral fluids, being of itself abundantly sufficient.

This evidence, which I have already given as to the cause of the fertility of boiled neutral fluids also goes far to undermine the foundations of the belief of other investigators as to the "survival of germs" in any previously boiled fluids. These beliefs all take their origin either from Pasteur's supposed proof of such a phenomenon, or from facts of a similar order to that by which he was supposed to have demonstrated it. The process is essentially this, and it has been often repeated:—1st, a deeply rooted conviction that living matter cannot arise *de novo*; 2nd, the finding of living matter in fluids which have been boiled or further superheated. Such a combination of fact and conviction leads to the facile conclusion that germs have survived the boiling, quite irrespective of the duration of the exposure. And similarly, the above-mentioned conviction continuing to be firmly rooted, the finding of living organisms in guarded fluids which have been heated to 230° F. may be immediately explained in the same way: "survival of germs" will be again the verdict, in spite of previous statements to the contrary, and independently of all evidence. Is fertility attained again, after another alleged death-point has been passed? Do fluids which have been heated to 248° F. ferment? First the facts are denied; and when these are established, again comes the causeless revocation of previous beliefs and the old cry "survival of germs."

To those who are wholly inspired by the conviction that a *de novo* origin of living matter is impossible, the following statements of experimental results will doubtless carry with them no significance, other than that above indicated. Still, for the sake of those who are not so imbued, it will be worth while to cite them.

Urine, almost neutralized with liquor potassæ, which has been heated to 212° F. for one to three hours in closed airless flasks will not unfrequently ferment in two or three days. A very little more or less of alkali, however, will with some urines suffice to prevent the occurrence of this change.

In sealed flasks half-full of neutralized urine, and half-full of ordinary air, which have been heated in a calcium-chloride bath to 230° F. for 5 to 30 minutes, fermentation takes place much more rarely. Still I have seen it occur fourteen times out of fifty trials—showing itself in the course of one to three days. In seven of these cases the fluids did not become generally turbid, though one or more tufts of Bacilli appeared in each: these were all specimens of the same urine which had been heated to 230° F. for 5 minutes. In the other seven instances there was very slight general turbidity, and the vessels had been heated to 230° F. for 30 minutes.

In twelve trials with faintly acid *beerwort*, partly of 1060 specific gravity and partly diluted to 1030, heated in tubes with air to 230° F. for 10 minutes, fermentation did not once occur; though, as in the experiments with urine, the fluids were, after this destructive heating, kept for many days at a temperature of 122° F.

The results with *hay*-infusion, acid *, neutral, and faintly alkaline, having a specific gravity of about 1005, have been much more successful. In each case about half an ounce of the fluid was used, half-filling a tube which was sealed when cold; so that above the fluid there was ordinary air. After heating the tubes in the calcium bath, some of them were exposed in the incubator to temperatures between 104°–113° F. (40°–45° C.), and others to a temperature of 122° F. In fourteen cases the infusions were heated to 230° F. for five minutes; and in every one of these organisms showed themselves within 36 hours. In twenty-one cases they were heated to 248° F. (120° C.) for 30 minutes; and in five of these latter trials (all with the same hay-infusion) no fermentation subsequently occurred. In the other instances more or less distinct fermentation supervened—though in some the signs of change before opening the vessels were only slight. The characters and organisms presented by these different fluids will be referred to in the next section.

* Only three times in this state. In the other cases liquor potassæ was added so as to make it neutral or slightly alkaline.

Six trials with neutralized *potato*-infusion, having a specific gravity of 1011, yielded no evidence of fermentation. Twice infusions were heated to 248° F. (120° C.), and four times to 230° F. (110° C.) for 30 minutes.

Sixteen trials with a neutral *cucumber*-infusion, having a specific gravity of 1003, heated to temperatures varying from 221°–248° F. (105°–120° C.) for 20 minutes were also attended by uniformly negative results.

But in forty experiments with good cows' *milk* heated in closed tubes half full of air to 230° F. (110° C.) for 5–60 minutes, and also in five other experiments in which the milk was heated to 240° F. (115°·5 C.) for 10 minutes, fermentation more or less marked occurred in each case in from 2–10 days.

The great variation in these results, especially with different fluids similarly heated, makes it seem almost impossible to account for them solely by reference to the death-point of germs, as some will doubtless attempt to do. Why should this death-point be so different in different fluids?

Then, again, these new experiments, like those which I have previously recorded, will be found entirely to contradict Prof. Cohn's position, that Bacillus is the only organism which appears when boiled or superheated fluids ferment. If it is true, as he says, that other organisms are all killed by temperatures below 212° F. (100° C.), when they are immersed in fluids, how are we consistently to explain the appearance of Micrococci and of Torulæ, some of which have been enabled to develop into typical and well-formed mycelia? The conditions and modes under which these different organisms appeared are now to be described.

VII. *Signs of Fermentation in the Boiled and Superheated Fluids employed in the foregoing Experiments.*

Urine.—The turbidity caused by precipitated phosphates will never, by the experienced worker, be confounded with that due to fermentation. He should, indeed, as far as possible, and except for special purposes, avoid dealing with urines which are prone to manifest this phenomenon. Sometimes in a slightly acid urine such a deposition takes place even before the urine attains the boiling-point, though at other times it only shows itself very slowly after the fluid has begun to boil. In urines of this latter type, it often happens that no clouding of the

fluid may be observed during the preliminary boiling over the flame, though after the closed vessel has been boiled in the can the fluid may be distinctly troubled, especially where the period of heating has been prolonged. When the cloudiness is very slight, it sometimes disappears as the urine grows cool; but when it is considerable, a thick white deposit gradually falls, which leaves the supernatant fluid quite clear. In cases where no phosphates have been deposited by the process of heating, this event may possibly occur on the breaking of the liquor-potassæ tube—though it will not often happen, if the amount of liquor potassæ added does not suffice actually to neutralize the urine in the experimental vessel.

All such deposits of phosphates, however, will soon subside after the vessel has been placed in the incubator, so that after twelve hours or less we have to deal with a clear supernatant fluid in which any subsequent turbidity may be easily discriminated. In airless vessels even the first haziness of the fluid seems to show itself uniformly throughout the liquid, and it is always accompanied by a slight diminution of colour. The urine becomes of an appreciably lighter shade. When the fermentation is vigorous, the haziness of the fluid rapidly passes over to a well-marked turbidity, which will generally continue for a long time and without the formation of the slightest scum or pellicle on its surface.

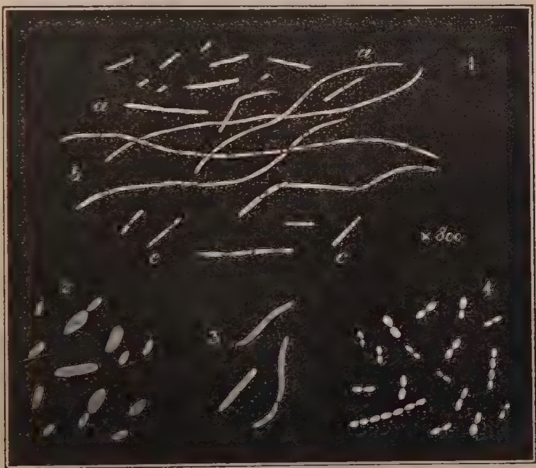
If the fermentation is less vigorous, it may manifest itself in one or other of three ways:—(*a*) It may never pass beyond a faint haziness of the fluid, even where the vessel is kept in the incubator for a week or two *; and in such cases the organisms are very scarce, not more than one or two being discoverable in any one field of the microscope †. A change of this kind is also often late in manifesting itself. (*b*) The fluid itself may remain perfectly clear; but at the sides of the vessel, or on some phosphatic sediment at the bottom, one, two, three, or more little whitish tufts may show themselves, which continue to increase in size for

* It is possible for an inexperienced observer to confound this condition with another in which the fluid remains quite unaltered, but in which the glass is attacked and made dim by the fluid. This occurs occasionally when some urines are kept long at a temperature of 122° F.; and it is especially apt to occur if the temperature should rise a few degrees above this point.

† A similar scantiness of organisms is also often met with in the blood of certain animals suffering from splenic fever, though in others they may swarm abundantly. (Quart. Journ of Micros. Science, Jan. 1877, p. 87.)

two or three days, the fluid itself still remaining perfectly clear. These are not tufts of some fungus, as might be thought from their appearance, but are tangled masses of long Bacilli-filaments*. (*c*) In other cases the fluid itself may remain clear, and no tufts may show themselves; but slowly, and after many days, more or less of a flocculent sediment accumulates at the bottom of the vessel in which organisms are to be found. This latter kind of change has not been much considered in this paper †; it is one which has only shown itself on a few occasions, and is, moreover, one which, judging from my previous experience, is more apt to

Fig. 7.



1. Urine *Bacillus*. *a*, *a*. Short, medium length, and long filaments. *b b*. Filaments bearing spores. *c*, *c*. Small fragments of such filaments.

2. Small *Torulæ* from hay-infusion.

3. *Vibrio Rugula* from hay-infusion.

4. *Micrococci* in the figure-of-8 form and as short chains, from milk and from hay-infusions.

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* Sometimes they have more the appearance of what Prof. Cohn describes as *Vibrio serpens* (Beit. zur Biolog. der Pflanz. Bd. i. Heft. 2, Taf. iii. fig. 18). But I entirely disbelieve in the propriety of regarding such differences as he distinguishes between these forms as having any generic or even specific value. Dr. Warming, of Copenhagen, says:—"Les Bactéries sont douées en réalité *d'une plasticité illimitée*, et je crois qu'il faudra renoncer au système de M. Cohn et de quelques autres savants qui caractérisent les genres et les espèces d'après leur forme." Quoted in 'Quart. Journ. of Microsc. Sci.,' Jan. 1877, p. 85. It is, however, only fair to add that Prof. Cohn is himself by no means free from doubt on the subject.

† See p. 3.

manifest itself when we deal with lower incubating-temperatures, as from 77°–96° F. (25°–35° C.), rather than with 122° F.

The fermentation which takes place in boiled or superheated urine is altogether different from that which occurs in unheated urine in open vessels. Even when the fluid has become quite turbid, it is never fœtid. The odour may be either quite unaltered in this respect, or, at most, there may be a slight increase of its urinous character *. As a rule, too, the organisms found are Bacilli (fig. 7, *a*), either short and unjointed (straight or bent); or longer, and representing what I have hitherto described as Vibriones; or, longer still, in the form of unjointed Leptothrix threads. I have all along contended that these were merely different forms of the same organism †; and now this is the accepted view, and they are all regarded, in accordance with the nomenclature of Cohn and Eidam, as Bacilli of different lengths. In airless flasks nothing like spore-formation shows itself in the filaments; so that in this respect the Bacillus of urine agrees with that of hay and of splenic fever. There is a still further agreement, since in open vessels, or in those which are merely plugged with cotton-wool, a scum forms on the surface of boiled urine inoculated with Bacilli in twenty-four hours—when at a temperature of 100° F. (38° C.)—composed, in the main, of filaments which within forty-eight hours will show the highly refractive bodies in their interior (*b*), and, indeed, partly break up (*c*) after this so-called "spore-" formation. All this agrees with the description which has been given by Cohn and Koch of the hay-Bacillus and of that of splenic fever. It is quite evident, therefore, that we must recognize the existence of a urine-Bacillus; but I do not on that account attempt to confer upon it any new specific name. Such a procedure would, I think, not only tend to confirm erroneous notions as to the distinctness of the life-history of these lower forms, but would be utterly useless even from the point of view of the species-makers. One might at once describe as new species and dignify with new names the Bacillus of turnip-infusion, that of cucumber, and of fifty other fluids. But would any rational end be attained thereby?

* In partly neutralized diabetic urine which has undergone fermentation in an airless vessel, I have on two or three occasions found an extreme fœtidity of the fluid; and this is, moreover, an extremely common occurrence where turnip-infusion ferments under the same conditions.

† See 'Nature,' July 14, 1870, p. 221.

Bacillus, however, is not the only organism to be met with in boiled or superheated urine; on rare occasions we may meet with other forms. Thus, where oxygen has been added by electrolysis, and where the reaction of the fluid has continued faintly acid, I have on two or three occasions found Bacteria composed of two little ovoid cells—something like *B. termo*, in fact, except that they are always quite motionless. These have been in cases where there has been a feeble fermentation of type (*c*); and in some of my earlier experiments with results of the same kind (though no oxygen was added), and where the incubating-temperature was from 86°–95° F., I have found figure-of-8 Micrococci together with short chaplets and small Torulæ. Lastly, in one or two specimens of partly neutralized diabetic urine with which I experimented this spring, I found, some days after the boiling, Torulæ growing freely in the midst of flakes composed of aggregated Bacilli. The odour of this fluid, when examined, was distinctly fœtid; and its reaction was neutral. As a rule, where well-marked fermentation occurs in urine which has been almost neutralized by potash, it is found at the time of examination to be faintly alkaline, owing to the liberation of ammonia during the process of fermentation.

Where the fermentation takes place in superheated vessels which have been sealed whilst the fluids were cold, so as to contain air, the process is apt to show itself first by slight turbidity near the surface of the fluid.

Hay-infusion, when treated in the manner last mentioned, and when it is heated to 230° F. (110° C.) or upwards, is also apt to show the change first at the surface of the fluid. When heated to this temperature we do not, as a rule, get any very well-marked turbidity. Nevertheless the fluid may grow perceptibly clouded; and whilst it becomes appreciably lighter in colour, a flocculent precipitate gradually accumulates. In other cases we may have whitish tufts of organisms manifesting themselves and visibly increasing in size whilst the fluid around remains clear. Lastly, in the least-satisfactory cases, we may have neither of the foregoing signs of change, but only a slow accumulation of a sedimentary matter, amongst which, in certain cases, organisms are to be found that are unquestionably living. Still it is also true that deposits of mere amorphous and crystalline matter will generally accumulate after a time at the bottom of even a well-filtered hay-infusion, in cases in which no fermen-

tation is initiated. Hence it is that this latter kind of change is unsatisfactory, and we need the microscope to tell us whether or not organisms are present.

It will thus be seen that the fermentation is almost always less vigorous in these superheated hay-infusions than where they are merely boiled; and its modes of manifestation are almost exactly the same as for urine. I have, however, met with some exceptions to this. Thus, last summer fourteen specimens of a hay-infusion which had been heated to 230° F. for five minutes, and which were subsequently exposed in the incubator to a temperature of 122° F., showed many Bacilli-tufts after twenty-four hours, which continued to grow for the next two days, the fluids themselves remaining clear. Then in several of the tubes the fluids, to my surprise, grew rapidly turbid throughout. Others, which had not yet undergone this change, I saved therefrom by removing them from the incubator to a cool drawer; and some of them are still in my possession with the remains of the Bacilli-tufts floating in the clear fluid. Two of these latter tubes I had examined at the time; and I then found that the tufts were composed of Bacilli, and, further, that there were scattered amongst the fibres a sparing number of mostly separate, small, ovoid Torula corpuscles (fig. 7, 2). Here and there these were more numerous and aggregated into clusters. It was not till several months afterwards that I examined one of the tubes in which the contents had become turbid, and which had in the interval been also put aside in a drawer. I then found the fluid more than usually *acid*, swarming with short Bacilli, whilst, much to my surprise, the

Fig. 8.

a, a. Fungus-mycelium. *b.* Torula corpuscles.

flakes were here composed of beautiful well-developed fungus-mycelia (fig. 8, *a*), which were growing over and more or less con-

cealing the original Bacillus-tufts with Torula corpuscles (*b*). Another of these tubes was then examined; and its contents were found to be altogether similar. The vessels were made of combustion-tubing; and having been sealed when cold, the ends were very strong and thick; they were thoroughly sound, as are others of them still in my possession *.

Superheated hay-infusion, when it ferments, invariably retains its characteristic odour, whether it has been heated in its natural acid state †, or when neutralized or made slightly alkaline by potash. In the process of fermentation an acid of some kind is generated, since even the slightly alkaline fluid may be found distinctly acid when we come to examine its contents microscopically. With regard to the organisms which are to be found in these fermenting hay-infusions, I have occasionally encountered, in addition to Bacilli of all lengths and Torulæ of various kinds, Micrococci in the form of figure-of-8 organisms or of short chaplets (fig. 7, 4). In the fluids previously referred to in which the Torulæ had developed into well-grown mycelia, I also met with a few organisms (fig. 7, 3) which seemed exactly to correspond with *Vibrio Rugula* of Cohn. These I have never seen in such fluids on other occasions.

Milk.—If heated to 230° F. (110° C.) for three quarters of an hour or more, milk is found to be distinctly discoloured by the process. It is then of a light fawn-colour. A briefer exposure, however, to this temperature does not appreciably affect its colour.

After it has stood in the incubator for twenty-four hours or so, a cream-like layer is found at the surface, the upper stratum of which is yellow and dry, though it is dotted here and there with globules of fluid oil. At this stage the fluid below is still white and opaque; but where fermentation ensues, it gradually becomes more and more whey-like, and at last it may assume the appearance of mere dirty water. If left for a long time, the fluid may undergo other changes, and after a time become much discoloured. If the milk has been heated to 230° F. for as long as 30 minutes or more, it may remain many days in the incubator at 122° F. before it shows any sign of change.

When a specimen of superheated milk has fermented and be-

* The supervention of a more vigorous fermentation, as shown by the turbidity, made the fluid more acid; and this change in the medium seems to have brought about the development of the previously existing Torula corpuscles.

† The acidity is always low, mostly equivalent to 1–2 minims of liquor potassæ per ounce.

come most notably altered in appearance, it still retains the simple odour of boiled milk. Its reaction, however, has changed, since it is always found to have become more or less acid.

When I first examined such a specimen of milk under the microscope, I was puzzled at not being able to discover any distinct or definite organisms amidst the milk-globules. It is true there was a teeming myriad of swarming particles every where, too minute to be individually recognized, and recognizable principally by their aggregate motions. These, however, might be organisms or might not; and, on the whole, I was inclined to take this latter view. The next specimen of fermented milk was, perhaps, examined with the aid of a better-adjusted light. At all events, I discovered therein a sparing number of Micrococci of the figure-of-8 type; and these have since been recognized in every specimen of superheated milk in which I have sought for them—where the fluid has presented the other signs of fermentation. They are to be recognized best in portions of the whey in which the milk-globules are not so abundant. They have a provoking habit of placing themselves vertically beneath the cover-glass, when they look just like small milk-particles; but as they turn over their proper shape is seen, and we find them composed of a delicate protoplasm presenting a much lower refractive index than the milk-particles with which they are intermixed. Once seen, therefore, they need never be confounded with couples of refractive milk-particles of about the same size, which are not unfrequently to be met with. The average length of these organisms is $\frac{1}{10000}''$; but sometimes they are rather larger, and at others they are distinctly smaller (Fig. 7, 4). Where the fermentation is not vigorous, the organisms are very scarce and mostly small; where it is better marked, they are not only larger, but sufficiently numerous to be pretty easy of detection. On only a few occasions have I seen a chain of four elements; the organisms almost invariably exist in the binary form. The same organisms are amongst the first to show themselves when unboiled milk turns sour in open vessels, though under such conditions they are speedily succeeded by several other more or less similar forms*.

* Micrococci of the same kind have also been found at times in some of my turnip and cheese experiments. I may take this opportunity of saying that I do not accept Prof. Cohn's interpretation of these experiments. Prof. Huitzinga showed that the small particles of cheese were not indispensable, and that they might be replaced by soluble peptones ('Nature,' 1873, vol. vii. p. 380).

VIII. *General Interpretation: present State of the Question in regard to Archebiosis.*

The germ theory of fermentation was adopted by M. Pasteur and the doctrine of "spontaneous generation" was rejected, in his celebrated memoir of 1862, on the strength of three principal inductions from his experimental work, together with three corollaries severally deduced therefrom.

Arranged in order, they may be stated as follows:—

Induction I. All guarded acid fluids remain barren after boiling.

Corollary.—Bacteria, Vibriones, Torulæ, and their germs are killed when they are heated in acid fluids for two or three minutes to a temperature of 100° C.

Induction II. Some neutral or faintly alkaline fluids, even though they are securely guarded, will ferment after boiling.

Corollary.—Certain Bacteria- or Vibrio-germs are not killed by being heated for two or three minutes in fluids to a temperature of 100° C., when these fluids have a neutral or faintly alkaline reaction.

Induction III. All neutral or faintly alkaline guarded fluids remain barren after they have been heated for a few minutes to 110° C. (230° F.).

Corollary.—All Bacteria- and Vibrio-germs are killed, even in neutral or faintly alkaline fluids, when these are raised for a few minutes to a temperature of 110° C.

These were the inductions and inferences to which the President of the British Association in 1870 gave his unqualified support, since it was in reliance upon Pasteur's views and researches principally that he proclaimed from his Presidential Chair the doctrine *omne vivum ex vivo* to be "victorious along the whole line."

If this could be said to have been an impartial verdict in 1870, it is one which is not likely to be repeated in 1880 on similar grounds*. Since the same year (1870) I have on various occasions and on various evidence contended that the first and third of these inductions were not good, and that the second corollary was neither warranted nor true. Additional and final proof of these positions has, I venture to think, been supplied in this memoir. I claim, therefore, to have shown that the grounds on which M. Pasteur, and the scientific world in general, following him, had accepted

* Whilst this is passing through the press No. 182 of the 'Proceedings of the Royal Society' has come to hand; and therein (at p. 353) I find a quotation from a recent lecture by Prof. Burdon Sanderson, in which he already acknowledges that,—"The outer line of defence represented by the aphoristic expression *omne vivum ex ovo*, has been for some time abandoned."

the "germ theory" of fermentation and rejected the doctrine of "spontaneous generation," were altogether insufficient and in great part erroneous—as a wider experience with other materials, new methods, and new experimental conditions has shown.

So far there seems to me to be no doubt. I have certainly shown the untenability of Pasteur's cardinal positions; and it was doubt on these points coming to a mind previously unbiassed, save in the direction of his doctrines, which first roused me to action. I found many authorities positively declaring that the question was settled by Pasteur's researches, which were regarded as crucial. If, then, on discovering, from my own work, that his most important positions could by virtue of other evidence be reversed, what wonder that I was positive in asserting that conclusions the opposite of Pasteur's were more harmonious with this evidence?

Meanwhile, during the seven subsequent years, the question has grown in all directions, and from all sides we have been receiving valuable accessions to our knowledge of the life-history of these lower organisms which are so intimately associated with fermentations, and with many diseased processes, not only in plants and lower animals, but in man himself. Thus a vast amount of fresh knowledge has been acquired which is not only of the highest interest and importance to the biologist, to the surgeon, and physician, but also, and this especially through the labours of Pasteur, even to the directors of large manufacturing industries.

The results of new investigations have shown themselves in multitudinous directions; but I now propose to draw attention only to some of them, since these particular additions to our knowledge have to a considerable extent reshaped the questions requiring solution before it can either be said by Pasteur that the "germ theory" of fermentation is firmly established, or by myself that the present occurrence of "spontaneous generation" is proven so far as it can be proved.

In the first place, then, it should be said that the distinguished founder of the "germ theory" of fermentation has himself seen cause greatly to modify his doctrines.

In 1862 M. Pasteur's view was that fermentations were chemical processes which could only be initiated and carried on under the influence of independent living organisms such as Bacteria, Torulæ, and their allies. In 1872* he extended this doctrine,

* Compt. Rend. vol. lxxv. p. 784.

and admitted that fermentative processes were not necessarily initiated by independent living organisms, since, following in the direction indicated by the researches of MM. Lechartier and Bellamy *, he had convinced himself that their *rôle* might be taken by the cell-elements of higher organisms when these exist under certain abnormal conditions.

In 1876 M. Pasteur † made a further concession, striking still more at the root of his original doctrine of 1862, since, after having repeated some investigations of M. Musculus ‡, he admitted that urine contained a separable chemical ferment, capable of inducing changes in that fluid similar to those which he had previously regarded as only to be brought about by living organisms. M. Pasteur, it is true, endeavoured to save the integrity of his already modified germ theory, on the ground that this not-living ferment is one which is called into being only by the previous activity of vital ferments—since, as he maintains, it is as a result of their ordinary life-processes that it is formed in the medium in which they exist.

Certain questions of much interest, to which it is important here to call attention, have arisen in connexion with each of M. Pasteur's extensions of doctrine.

In regard to the extension of 1872, it may be asked whether in all cases the fermentations initiated by the chemical changes taking place in fruits placed under unhealthy conditions (as in an atmosphere of carbonic acid gas) are always unaccompanied by the appearance and development of ordinary ferment-organisms. And in reply, it must be said that the researches of Lechartier and Bellamy have shown that Bacteria constantly make their appearance when experiments of this kind are made either with the beetroot or the potato. This is declared to be an event of invariable occurrence; and the fact seems to be admitted by M. Pasteur, though, on the other hand, he denies the statements of MM. Fremy § and Trécul to the effect that organisms are also habitually developed within the cells of many fruits in which the so-called "intracellular" fermentation is taking place.

But though he does not deny the occurrence of organisms, M. Pasteur has not, so far as I am aware, made any good attempt to account for their invariable appearance in the beetroot and the

* Comptes Rendus, 1869, 1872, and 1874.

† Ibid. vol. lxxxiii. p. 5.

‡ Ibid. Jan. 31, p. 333.

§ 'Sur la Génération des Ferments,' 1875, pp. 179–191.

potato, or to show that they are not heterogenetic products. Yet their customary absence from the tissues of such vegetables under ordinary conditions, and their presence when these are placed under certain unnatural conditions (which of themselves by no means favour contamination), makes this seem a not unreasonable explanation of their presence. I merely call attention to these points now, without venturing to express any opinion of my own, as they are parts of the subject to which, as yet, I have given little attention.

Then, in regard to the extension of M. Pasteur's doctrine in 1876, and the confirmation by him of the fact discovered by M. Musculus that fermenting urine contains a soluble chemical ferment separable from and capable of inducing in urine precisely the same sets of changes as ferment-organisms produce therein, several questions of much interest arise, which have as yet received surprisingly little attention.

Granting that this newly discovered chemical ferment is, as M. Pasteur declares, a product of the life-activity of ordinary ferment-organisms, we want to know (*a*) what the effect would be of introducing some of this separated chemical ferment into sterilized urine, and whether, as a result of its action the ordinary ferment-organisms ever appear in the fluid. We also want to know (*b*) what exact degree of heat this chemical ferment is capable of undergoing without losing its activity,—whether, in fact, it is decomposed at temperatures higher or lower than those sufficing to kill or arrest the activity of the living ferment-organisms by which it has been produced. We ought to know (*c*) how it is affected by desiccation and, if minutely "particulate," like Dr. Sanderson's pyrogen *, whether such desiccation will subsequently enable it to resist a higher degree of heat in fluids than it could previously withstand. And lastly (*d*) we want to know how many different kinds of chemical ferments may be found in urine under different conditions, whether similar ferments are engendered during the course of many other fermentations, and whether they are generally like pyrogen particulate in nature, or soluble, as zymase (the "ferment inversive" of Berthelot) is reputed to be.

Such not-living chemical principles resulting from the life-activity of independent ferment-organisms seem altogether analogous to those longer known chemical ferments of the animal body and of the plant, which are capable of exciting analogous

* Brit. Med. Journ., Feb. 13, 1875, p. 201.

chemical actions. The most familiar of such bodies are ptyalin, pepsin, pancreatin, of animal origin, with diastase, emulsin, and myrosin, as products of certain vegetable tissues. And when we learn that the actions brought about by these bodies are also nearly all of them capable of being induced by mere acids and alkalies acting under known conditions, much of that air of mystery seems stript from fermentative processes which Pasteur's definitions are calculated to inspire*.

The products of the animal and the vegetal organism are many of them capable of being built up by synthetic processes in our laboratories. No one now will venture to say that though such or such bodies can be artificially engendered, certain other organic compounds cannot, and never will be, so produced; and the same may be said in regard to actions supposed only to be producible by the direct agency of living units. As M. Schutzenberger says, in the preface to his work on 'Fermentation':—"If living cells produce reactions which seem peculiar to themselves, it is because they realize conditions of molecular mechanism which we have not hitherto succeeded in tracing, but which we shall, without doubt, be able to discover at some future time. Science can gain nothing by being limited in the possibility of the aims which she proposes to herself, or the end which she seeks."

But we must now turn to another side of the question, and see how, with increasing knowledge and new surmises concerning the death-point and life-history of ferment-organisms, possibilities of a new order in regard to their survival under adverse circumstances have been opened up. We must try also to estimate their relative worth.

In the year 1871† I made the first recorded experiments to ascertain at what precise temperature below 212° F., Bacteria, Torulæ, and their germs were killed. These experiments were conducted by adding a drop or two of a fluid swarming with such organisms to an artificially prepared nourishing solution (having a *neutral* reaction), in which they had been found to multiply rapidly, and then after exposing this inoculated mixture to definite temperatures for a certain time, putting it aside under favourable conditions to see whether it would or would not become

* Schutzenberger, 'On Fermentation' (English translation), in International Scientific Series, 1876, pp. 269–307.

† 'Modes of Origin of Lowest Organisms,' 1871, p. 50.

turbid*. Acting in this way I found that fluids heated to 131° F. (55° C.) for ten minutes would ferment, but that when heated to 140° F. (60° C.) for the same period they remained quite clear and pure. I inferred therefore that the temperature of 131° F. was not sufficient to kill, but that one of 140° F. was adequate to destroy the organisms and germs introduced into the nourishing liquid. I also ascertained that when the exposure to heat was prolonged to four hours such organisms were killed at still lower temperatures†.

In the following year Prof. Cohn and Dr. Horwath made almost similar experiments in regard to the death-point of Bacteria, but not for Torulæ. It does not appear that they were then aware of my investigations. They, however, arrived at results almost precisely similar, as may be seen when Prof. Cohn ‡ says:—"These experiments demonstrated without exception that no Bacteria were developed in the flasks which were kept at a temperature of from 60°–62° C. for an hour, and that the contained fluid remained clear; on the other hand, flasks containing Bacteria fluid which had only been heated to 50° C. or 40° C. became clouded, in consequence of the multiplication of Bacteria, in a time varying from two to three days."

"One need scarcely mention," he adds, "that in flasks heated to 70°, 80°, 90° C. there was never any cloudiness. The fact that the cloudiness in a flask which has only been subjected to a temperature of 50°–52° C. for one hour shows itself much sooner than in one which has been kept at the same temperature for two hours, leads one to suppose that 60° C. is apparently not the lowest temperature at which Bacteria are killed, but that perhaps a lower degree of heat would be sufficient to prevent their multiplication."

In the year 1873 I returned to this subject in order to ascertain whether Bacteria and Vibriones would be killed at the same temperatures in organic infusions as they had been found to be in a neutral saline solution. A large number of experiments were

* The nourishing liquid employed was much simpler than that of Pasteur or of Cohn, since it consisted merely of a 2 per cent. solution in distilled water of the neutral ammonium tartrate with about $\frac{1}{2}$ per cent. of a neutral sodic phosphate. I had ascertained even in 1870 ('Nature,' July 14, p. 222) that both Bacteria and Torulæ would grow and multiply in a simple solution of ammonium tartrate, and therefore had recognized before Prof. Cohn that these organisms could take their carbon from such a compound as tartaric acid.

† 'Modes of Origin of Lowest Organisms,' 1871, p. 59.

‡ Beiträge zur Biologie der Pflanzen, 1er Bd., 2tes Heft, 1872, p. 219.

therefore made with *neutral* hay-infusion and with *acid* turnip-infusion inoculated with drops of a fluid swarming with the above-named organisms. The mixture was exposed to the several degrees of heat only for a period of *five* minutes. In a communication to the Royal Society, after classifying the results, I say*:—"The experimental results above tabulated seem naturally divisible into three groups. Thus, when heated only to 131° F., all the infusions became turbid within two days, just as the inoculated saline solution had done. Heated to 158° F., all the inoculated organic infusions remained clear, as had been the case with the saline solutions in my previous experiments when heated to 140° F. There remains, therefore, an intermediate heat-zone (ranging from a little below 140° F. to a little below 158° F.) after an exposure to which the inoculated organic infusions are apt to become more slowly turbid, although inoculated saline solutions raised to the same temperatures invariably remained unaltered." The cause of these discrepancies was further studied; and in a subsequent communication to the Royal Society a few months later, I adduced evidence to show that the turbidity which had occurred after the organic inoculated fluids had been subjected to a heat of 140° F. (60° C.) and upwards to 158° F. (70° C.) had been due "not to the survival of the living units, but rather to the fact that the mere dead organic matter of the *inoculating compound* has acted upon the more unstable organic infusions in a way which it was not able to do upon the boiled saline fluids"†. The inoculating compound made use of in these experiments being a fluid in full fermentation, it would contain, besides organisms and their germs, mere organic matter, and, as the light of subsequent investigations enables me to add, possibly some soluble chemical ferments produced during the vital activities of the living organisms themselves.

These experiments were devised and carried out solely with the view of throwing light upon one particular question, viz. the thermal death-point of Bacteria and their germs when immersed in fluids. Those of the first series also had the same reference to Torulæ and their germs. Having such an object before me I was careful to eliminate any source of confusion which might arise from the possible germinality of the mere fluids with which expe-

* Proceedings of the Royal Society, vol. xxi. p. 231.

† Ibid. pp. 325–330.

riment was made. I ascertained first of all, therefore, that the fluids destined to be employed under certain definite conditions as nourishing fluids were capable of acting efficiently as such, and that under those particular conditions they never of themselves behaved in such a manner as to make it possible to think that a *de novo* production of living matter would occur therein. This source of doubt being eliminated, one could watch the effects of inoculating such fluids with living Bacteria and of subsequently heating the mixture to different degrees, and draw tolerably safe conclusions therefrom. Without such a precaution it is obvious that, in the present state of this question, great mistakes might be made, since effects possibly due to the germinality of the fluids as such might be attributed to a supposed survival of the germs which had been heated in the inoculated fluids. I feel by no means sure that some of the recent investigators working in Prof. Cohn's laboratory have been quite so mindful of this point as they should have been.

I believe my experiments to have shown that a temperature of 140° F. (60° C.) is destructive to Bacteria, Vibriones, Torulæ, and their germs in a neutral saline solution, and that the same temperature is also destructive to Bacteria, Vibriones, and their germs both in a *neutral* hay-infusion and in an acid turnip-infusion. Even if we allowed the opposite interpretation to stand in regard to those cases with the organic infusions in which there was some room for doubt, we should still have to raise the death-point only to 158° F. (70° C.), and this, too, when the exposure to such a temperature had only been prolonged for five minutes.

Not the least countenance was given to M. Pasteur's notion that Bacteria- and Vibrio-germs could resist a higher temperature in neutral than they could in acid fluids. If there was any difference as between neutral hay- and acid turnip-infusion, it seemed slightly in the other direction.

These experiments were supposed to hold good, as I pointed out at the time, for "germs" as well as for the parent organisms*. The nourishing media were inoculated with a fluid in which Bacteria and Vibriones were multiplying rapidly, so that we had a right to infer that they were multiplying in their accustomed manner. I then said, "These experiments seem to show, therefore, that even if Bacteria do multiply by means of invisible gemmules, as well as by the known process of fission, such invisible

* Proceed. of Royal Soc. vol. xxi. p. 227.

particles possess no higher power of resisting the destructive influence of heat than the parent Bacteria themselves possess."

In 1875 Professor Tyndall began to work at this subject and announced his results early in the following year*. He did not endeavour to ascertain the lowest temperature which would prove destructive to Bacteria, Torulæ, and their germs, though he came to the conclusion that they were always killed by being boiled for five minutes in organic fluids, and he seemed to imply that this result was irrespective of the precise degree of acidity or neutrality of the fluids employed†. Since this conclusion as to the death of ferment organisms and their germs in infusions raised for a few minutes to 212° F. was based upon about five hundred experiments with fluids of the most varied nature, Prof. Tyndall seemed to feel considerable confidence in its truth. So far as it went, therefore, his evidence on this part of the subject was entirely confirmatory of mine. Indeed, in the beginning of 1876, Professor Tyndall's views on this important subject were as much opposed to those of M. Pasteur as mine were; we both disbelieved, as we thought, on good evidence, in the survival of germs in boiling neutral or faintly alkaline fluids.

At this time M. Pasteur's positive results with some of such fluids would seem to have been forgotten by Prof. Tyndall. At all events, not being able himself to get evidence that any boiled and guarded fluids would ferment, he attempted to throw discredit upon me because I had obtained such results. Forgetful of Pasteur's experiments above referred to, and apparently unaware of the confirmation which my experimental facts had obtained at the hands of many independent workers, he triumphantly brought forward a "cloud of witnesses" to convince the Royal Society and the world of science generally, as well as others, that my particular results in which fermentation had been made to show itself in boiled and guarded fluids were due to experimental errors into which it was conjectured that I had easily fallen, since it required all Prof. Tyndall's great skill and long experience to avoid them. He strenuously denied that a certain experimental result could be obtained when strict methods were followed. It was as regards the question of fact, rather than in regard to its interpretation, that Prof. Tyndall then did his best to throw discredit upon my work.

* Philosophical Transactions, 1876, pt. i. p. 27.

† *Loc. cit.* p. 51.

All this confident assertion and conjecture on the part of the new worker was based upon his belief, and is to be taken as the measure of his certainty at that time, that Bacteria and similar organisms, with their germs, were killed by being heated in fluids to 212° F. for a minute or two. It is, in truth, even now almost impossible otherwise to account for the continued barrenness of his 500 various fluids, placed, as he says, under conditions favourable for the multiplication of any organisms or germs which they might contain, not for days only, but for weeks and even months.

Professor Tyndall seems entirely to have misconceived the real aspect of the question as it stood before the scientific world in the beginning of 1876. He unhesitatingly coincided with me as regards the only point which was really in dispute, viz. whether the "omnipresent" ferment-organisms and their germs were killed by a brief boiling of them or not; whilst the fact which he called in question was the very point which had been abundantly confirmed and was then generally admitted, whatever interpretation might have been put upon it by different experimenters*. Indeed, what Prof. Tyndall had been unable to achieve in the way of inducing fermentation in boiled and guarded fluids, had three years previously been brought about by me in the presence of a highly skilled and then sceptical witness, Professor Burdon Sanderson. He subsequently published his declaration† that positive results, both with acid and with neutral boiled infusions, had been obtained without experimental flaw; yet in spite of this testimony, and without even mentioning it, Prof. Tyndall sought to decry my experiments and set aside my results.

Meanwhile, almost at the time that the learned physicist was acting in this bewildering manner, one of the principal authorities on such subjects in Europe, Prof. Ferdinand Cohn, was again confirming my impugned experiments, at Breslau, and was obtaining, both with acid and with neutral boiled infusions, those evidences of fermentation which hitherto Professor Tyndall had strangely enough failed to reproduce‡. The fact was again fully admitted by Prof. Cohn, though my interpretation of it was still questioned. It is therefore quite needless for me here even to

* For a list of such experimenters see 'Nature' Feb. 10, 1876, p. 284.

† 'Nature,' Jan. 8th, 1873.

‡ 'Beiträge zur Biologie der Pflanzen,' 1876, p. 259. This confirmation, after Prof. Tyndall's denial, was very similar in its opportuneness to that of Prof. Sanderson after E. Ray Lankester's denial (Quart. Journ. of Microsc. Science, Jan. 1873, vol. xiii. p. 74).

cite the other investigators who had previously obtained similar results. This side of the question has, in fact, been so thoroughly settled by my experiments, and the numerous confirmations which they have received at the hands of others, that it would be waste of space for me now to dwell further upon this part of the subject.

It must be obvious that what we need at present is all the definite evidence that can be obtained as to the thermal death-point, and as to the powers of resistance under different conditions, of ferment-organisms and their germs. Thus it is that I now restrict my remarks almost wholly to investigations bearing directly or indirectly upon this section of the subject.

Twelve months later, we find Prof. Tyndall* announcing that he was then able to obtain the previously denied results. The behaviour of his recent infusions had completely stultified his previous position. He was no longer at issue with me and others in regard to the fact. The difference between us was now one of interpretation only. In spite of his previously much-vaunted 500 negative results, and the good evidence which they supplied as to the death-point of Bacteria and their germs, Prof. Tyndall now endeavoured, as best as he could, to cover his previous unfortunate position. The result was a complete change of front.

During all his earlier experiments, though operating in the midst of London in an air which he had himself not lightly stigmatized, in many trials with all sorts of fluids, he had not come across a single germ which could survive the influence of boiling water for a few minutes. Desiccation of germs, according to Prof. Tyndall's experience at this time, would seem to have been a phenomenon of the rarest occurrence; germs capable of resisting a short boiling must have been almost, if not quite, unknown.

But no magician with his wand ever wrought a more complete change than did Prof. Tyndall by introducing a bundle of "old hay" into his laboratory. Henceforth there was evidence of fermentation in boiled fluids without stint, desiccated germs were everywhere—germs capable of resisting even two, three, four, and more hours of boiling everywhere surrounded him and got into his infusions.

These, at least, are the hypotheses by which Prof. Tyndall endeavoured to reconcile his earlier with his later results. But two things strike one as very unsatisfactory in regard to them and

* Brit. Med. Journ., Jan. 27, 1877, p. 95.

his method of supporting their cogency. In the first place, it may be observed that the fact of his having introduced a bundle of "old hay" into the laboratory of the Royal Institution cannot be regarded as a satisfactory explanation of the results of myself and others who had been able to obtain fermentation in boiled fluids long before, without the aid of any such magician's wand as this which Professor Tyndall had chanced to employ. Secondly, there is the very dubious nature of the evidence by which he has sought to support his interpretation, and the absence of any thing in what he has yet published on the subject which gives any definite or independent foundation to his new hypotheses. Thus, to take one illustration, in the Proceedings of the Royal Society* there is printed a note "On Heat as a Germicide when Discontinuously Applied," in which Prof. Tyndall says:—"Following up the plain suggestions of the germ-theory, I have been able, even in the midst of a virulently infective atmosphere, to sterilize all the infusions by a temperature lower than that of boiling water. * * * Before the latent period of any of the germs has been completed (say a few hours after the preparation of the infusion), I subject it for a brief interval to a temperature which may be under that of boiling water. Such softened and vivified germs as are on the point of passing into active life are thereby killed; others not yet softened remain intact. I repeat this process well within the interval necessary for the most advanced of those others to finish their period of latency. The number of undestroyed germs is further diminished by this second heating. *After a number of repetitions, which varies with the character of the germs, the infusion, however obstinate, is completely sterilized.*"

Noting by the way that the "character of the germs" has no other reality than Prof. Tyndall chooses to infer from the obstinacy of the infusion in resisting sterilization, it is only necessary further to point out that the above procedure and its results allows absolutely no conclusion to be drawn in favour of the survival of germs, except by ignoring the only other legitimate interpretation. The frequent repetitions of destructive heating might, after a time, repress all tendency to fermentative change in a fluid with the same facility that it might destroy germs supposed to be successively awakening to life and activity. If an investigator has decided beforehand that one of these possibilities is not worth

* No. 178, vol. xxv. p. 569.

thinking of as an interpretation, the problem, to his mind, is, of course, a simple one.

It is true, however, that the course of events between the period of the publication of Prof. Tyndall's first and that of his second paper did give to his explanation of these second results some semblance of support—although they were, at the same time, in rather flagrant contradiction with the uniformly negative results of his first five hundred trials.

The new point of view introduced in the mean time through the labours of Professor Cohn, in conjunction with those of Dr. Eidam and Dr. Koch, was thus brought about.

Dr. Eidam* carried out some researches in 1875 under Prof. Cohn's direction as to the exact death-point of *Bacterium termo*. He ascertained that this organic form always disappeared in fluids heated to a temperature of 113° F. (45° C.), though Bacilli were found growing and multiplying rapidly therein. In the following year these researches were continued in regard to Bacilli, and the results are given by Prof. Cohn† in his own memoir on these organisms, which was published in the autumn of 1876. The points of most significance therein recorded are (*a*) that Bacilli are the organisms which commonly make their appearance when previously boiled fluids undergo fermentation; (*b*) that at a temperature of 37° C., or thereabouts, when the infusions are exposed to air through a cotton-wool plug, these Bacilli grow into threads which accumulate in the form of a pellicle on the surface; (*c*) that in twenty-four to forty-eight hours a number of highly refractive particles appear at short distances from one another within the threads, which are to be regarded as "spores"; and (*d*) there is a certain amount of evidence, but not of a conclusive character, to show that these "spores" in a dry condition may resist heat much better and for a longer time than their parent organisms. This latter evidence is inconclusive, principally because no sufficient precautions were taken to show that what was attributed to survival of germs might not have been really due to a still-continuing germinality of the fluids, though also in part because the possible action of mere chemical ferments was not duly considered.

These points were reenforced in the same number of Prof.

* Beiträge zur Biologie der Pflanzen, 1er Bd. 2tes Heft, p. 208.

† Ibid. 2er Bd. 2tes Heft, p. 268.

Cohn's journal in an important paper by Dr. Koch entitled "Die Aetiologie der Miltzbrandkrankheit." The organism met with in this disease is also a Bacillus, indistinguishable by the microscope from that found in hay-infusions. When exposed to air at a temperature of about 37° C. it also grows into filaments, which speedily develop therein the highly refractive spore-like bodies, and then become disintegrated. Koch found, moreover, that the Bacilli themselves of splenic fever could only resist a comparatively short amount of desiccation, though he concluded from his experiments that the spores could retain their vitality and power of communicating the disease for years when imbedded in the midst of certain dried matter. No sufficient details, however, are given in regard to this latter point; and it cannot be considered that Koch's evidence proves that Bacilli spores can resist prolonged periods of desiccation, (1) because he found that the splenic-fever matter, containing germs, was only potent when pieces of spleen or blood in mass were dried, in *the midst of which the germs may not have been really desiccated at all*; and (2) because it has not yet been distinctly proved that it is the actual spores, or only the spores and not certain chemical principles in the medium, constituting soluble or 'particulate' ferments, which communicate the disease. *Any such chemical principles might preserve their integrity in the midst of the colloid masses above mentioned just as well as spores.*

This latter consideration is especially strengthened by recent accessions to our knowledge. Thus we learn from Dr. Koch himself that though the hay-Bacillus is so similar to the Bacillus of splenic fever as to be microscopically indistinguishable therefrom, yet that the former organisms are quite powerless to excite splenic fever when inserted beneath the skin of rabbits. And although it may be said that morphological similarity does not necessarily imply identity in the physiological or molecular actions of the two organisms, yet it may fairly be insisted that, as regards these two organisms in particular, there is evidence that in all outward respects their course of life and properties are also similar. But even greater need for caution in the same direction might be brought home to us by the now admitted fact that the common septic ferment excretes or helps to form a chemical principle *, existing, according to Prof. Burdon Sanderson, in the form of minute

* Just as other allied organisms give rise to grains of blue or other pigment in the jelly which envelops them.

particles capable of generating a febrile illness resembling septicæmia, which the organism itself is unable to produce—and also from the fact discovered by Musculus, and confirmed by Pasteur, that a soluble ferment exists in fermenting urine, separable therefrom, and which is capable of producing precisely the same changes in this fluid as may be initiated by the living ferment itself.

Yet, relying principally upon this evidence of Koch, Prof. Cohn postulates for the spores of hay-Bacilli a power of resisting prolonged and thorough desiccation. And although Koch says distinctly that he found no evidence of a survival of power to communicate the disease when he dealt with small fragments of splenic-fever matter which had been dried, Cohn assumes that for hay-Bacillus even separate spores, or spores in association with very small particles of matter, may preserve their potency; nay, further, that the conduction of heat no longer takes its ordinary course in regard to such particles—so that they may remain for hours immersed in fluids at temperatures destructive to all other visible forms of living matter. Before all these difficulties I may perhaps be pardoned for saying that I am not ready to yield assent to the popular view. Mere surmises and guesses must make way for definite knowledge acquired by accurate and crucial experimentation. But as yet there is nothing of this sort to support the notion of the ability of the ferment-organisms to endure complete desiccation, and that in this state they are able to resist for a prolonged period the otherwise destructive influence of heated fluids.

A fatal lack of precision seems to have pervaded all attempts which have yet been made to deal with the question of the ability of organisms or their germs to resist desiccation. This lack of precision is seemingly due to the fact that the mind of the experimenter is generally to a great extent biased by the notion of the impossibility of a generation *de novo* of living matter. Just as we have previously seen Pasteur inoculating barren fluids with organic débris &c. filtered from the air, and assuming that the fertility which ensues *must* have been due to this matter containing living germs, so, more recently, we find other experimenters subjecting such matter and the organisms which it may contain, or subjecting organisms and portions of the media in which they have been flourishing, to desiccating influences, and invariably attributing any supervening fermentation or disease which

such matter may set up to the survival of the organisms, when the above-named results may have been due to the survival of mere chemical ferments or 'particles' in such desiccated media. This objection I pointed out in 1872 *, and it is one which must be met before conclusive experiments can be made. Fortunately the means for complying with this necessity are now within the reach of all skilled experimenters†. This kind of differentiation requires to be made especially by those who announce positive results. It would be a matter of less urgency wherever accurate experiments show an inability to resist desiccation, or to resist this process *plus* the brief influence of boiling water.

Before referring to a few inquiries which I have myself made in these new directions, it seems desirable to say a few words concerning one other attempt to raise the standard of vital resistance to heat for the germs of some organisms, as this particular evidence has been frequently mentioned during the last year—in fact, ever since Prof. Tyndall's contradictory experiments had in some way to be explained. Nothing better shows the paucity of any thing like exact knowledge concerning the ability of living matter to withstand a temperature of 212° F. and upwards, together with the strongly felt desire of the panspermatists to find it, than the altogether undue importance which has of late been attached to this evidence, which was brought forward nearly four years ago by the Rev. Mr. Dallinger and Dr. Drysdale.

These gentlemen are now well known as the authors of some very elaborate and meritorious investigations on the life-history of certain flagellate monads. In addition to reproduction by the well-known process of multiple fission, they have described two kinds of germs, one minute, but easily visible, and the other so minute as to be quite indistinguishable individually, even by the highest powers of the microscope. Some observations have been made as to the effects of different temperatures upon the parent forms and upon these reproductive units. The manner in which this investigation was conducted is thus described by the authors ‡:—"An ordinary slide containing adult forms and sporules covered in the ordinary way was allowed to evaporate slowly in

* 'The Beginnings of Life,' vol. ii. p. 4.

† Brit. Med. Journ., Feb. 13, 1875, p. 201.

‡ Monthly Microsc. Journ., Aug. 1873, p. 57.

seven instances, and placed in a dry heat which was raised to 121° C. It was then slowly cooled and distilled water allowed to insert itself by capillary attraction. On examination, all the adult forms were absolutely destroyed, and no spore could be definitely identified. But after having been kept moist in the growing stage for some hours, and watched with the $\frac{1}{50}$, gelatinous points were seen in *two out of the seven cases*, which were recognized as exactly like an early stage of the developing sporule, which were watched till they had reached the small flagellate state shown in fig. 5, pl. xxvi. The remaining five were barren of result." Other observations were detailed in a subsequent number of the same Journal *; but that above quoted is typical as regards the method, aud not far from typical as regards the results, which may fairly be described as eminently contradictory in nature. All the observations which these experimenters record I have tabulated, so that it may be seen what their evidence really amounts to :—

Nature of Heat-exposure.	*Survival of Spores.*	*Survival of Sporules.*
93°·33 C. (200° F.) for ten minutes.	On 3 slides out of 6.	On 3 slides out of 6.
"Raised to 121° C."	On 2 slides out of 7.	No observations made.
121°·11 C. (250° F.) for ten minutes.	Statement of results not precise, uncertain whether both *germs* and *sporules* developed in only 1 or in 4 out of 5 slides.	
"Heated up to 148°·88 C." (300° F.).	On 2 slides out of 6.	On 3 slides out of 6.

The authors say that these "are only typical results of a larger series of experiments." They are perhaps more typical than significant: they are assuredly very perplexing. Why, with such apparent uniformity of conditions, should there be so much discord in results? These remarkable *sporules* would seem to be better able to withstand a momentary exposure to a temperature of 148° C. than one of the same duration to 121° C., and just as well able to bear this heat as an exposure for ten minutes to the very different temperature of 93°·30 C.

But why should the authors have deliberately thrown an ele-

* March 1874, p. 99.

ment of confusion into the subject which was wholly needless and easily to have been avoided?

The effects of dry heat (which is well known to be less damaging to life) are set forth when it would have been quite as easy and much more satisfactory to have given instead, or, in addition, the effects of heat upon these organisms and their germs when they were in the moist state *. The consequence has been that these results with dry heat have been quoted by subsequent writers as though they fell into the same category as others which have been made with moist heat; and differences of result which, in the main, have been due to different modes of exposure, have been ascribed to different powers of resistance on the part of simple organisms and their germs. Professor Tyndall, indeed, has gone so far as to speak of the "grave error" which biologists have hitherto made in failing to recognize this important distinction concerning germs and organisms respectively; yet, as a matter of fact, the possibility of such a difference has been clearly before the minds of all the principal workers on these subjects from the time of Spallanzani downwards †.

But the fallacy of all this may be seen from the fact that in 1862 M. Pasteur ‡ himself found that certain of the germs or spores of fungi, especially those of the common mould *Penicillium*, would germinate after exposure to a dry heat of 121° C. (250° F.) for thirty minutes, though, as he says in an earlier part of his memoir (p. 60), he had proved by direct experiment that when immersed in fluid, even for a few minutes, at a temperature of 100° C., all such germs were killed. Seeing that, according to the experience of Dallinger and Drysdale, their spores and sporules, in the dry state, were no better able to resist the momentary influence of 121° C. than of 148° C., and that Pasteur found spores which could resist a dry heat of 121° C. even for *thirty minutes* were yet invariably killed when immersed in boiling water for two or three minutes, there is no reasonable ground whatever

* It would have been perfectly easy to have put one or two drops of the fluid into a small tube, to have hermetically sealed it, and then to have heated it for 10 minutes or more to different degrees before subjecting the fluid to a prolonged microscopical examination upon a carefully prepared slide.

† In my 'Evolution and the Origin of Life,' 1874, pp. 141–168, Spallanzani's views on the subject are set forth and duly considered, as well as all other evidence that was at the time available.

‡ Ann. de Chim. et de Phys. t. lxiv. pp. 92–99.

for supposing that the germs and sporules of the monads would be more fortunate in surviving such an ordeal *.

I have as yet only had time to commence the study of the amount of heat which the Bacilli "spores" will resist as compared with the organisms from which they are derived. I began by endeavouring to ascertain whether these bodies were or were not capable of resisting a brief immersion in boiling water.

Dealing first with the Bacilli of urine, I procured a good supply of spores by inoculating an almost neutral specimen of boiled urine, contained in a flask plugged with cotton-wool, with another specimen of urine already swarming with such organisms, and placing the mixture in an incubator at 38° C.† In the course of two or three days a scum formed, in the threads of which spores were abundantly developed, and the fibres themselves during these and the two or three subsequent days broke up very extensively. This liquid (A), thoroughly well shaken, gave me a fluid teeming with Bacilli spores. Another liquid (B) was prepared by causing neutral urine to ferment at a temperature of 122° F. in an airless vessel. In this fluid, whilst the Bacilli themselves were swarming, their germs or spores were absent.

A number of bulb-tubes were then taken, and each of them was charged with one ounce of a urine whose acidity was equivalent to from 12 to 15 minims of liquor potassæ per ounce. Such a fluid is one which can be easily and certainly sterilized by heat, and this, of course, is an essential property for any nourishing liquid which is to be used in experiments as to the death-point of organisms. The ultimate object of such experiments being to enable us to decide not only as to the conditions under which a retention of life is possible in certain organisms, but to supply evidence bearing upon the possibility of a generation *de novo*, it seems absurd that an investigator should think of using in these death-point experiments a fluid possessing doubtful qualities—that is, one which, whilst it is known to be a nourishing fluid, may also be something more, a generating fluid. Yet it seems to me that Prof. Cohn's

* The observations of Pasteur, indeed, as well as of Tarnowski, tend strongly to show that the *spores* of the lower fungi generally are killed in fluids by a brief exposure to 60° C. (140° F.).

† At this temperature the boiled neutral fluid might not have fermented for many days; hence the fluid was inoculated in order to shorten the process.

and Dr. Eidam's experiments with Bacillus are to some extent open to this objection.

In acid urine of the kind mentioned we have a nourishing medium which, after ten minutes' boiling, is certainly not a generating medium. If, therefore, we charge a number of vessels with some of this liquid, to which fluid A has been added* in the proportion of one minim to the ounce, and another series with some of the same liquid to which fluid B has been added in similar proportions; and if we subsequently heat these mixtures to a similar extent, we shall be able to test the power of resistance to heat pertaining to the spores in liquid A compared with that pertaining to the mere rods and filaments in fluid B.

This I carried out in the following manner:—The necks of the bulb-tubes were drawn out in the blowpipe-flame, and the fluid within each was boiled over the flame for about a minute. The neck of the tube was then hermetically sealed, after which it was plunged into a vessel of boiling water, where it was allowed to remain for exactly ten minutes †.

The fluids of the two series similarly heated were then placed side by side in the incubator at 122° F. (50° C.), and the result in 25 trials (19 containing fluid A, and 6 containing fluid B) has been that not one of either series has fermented, though the tubes were kept from ten to fourteen days in the incubator. Yet in control experiments with the same urine boiled for ten minutes in plugged flasks and subsequently inoculated with an unheated drop of fluid A and of fluid B, fully developed fermentation was invariably set up in from sixteen to twenty hours—showing clearly that there was nothing in the nature of the fluid to impede the development of the organisms.

Having ascertained that hay-Bacilli also increased with about equal readiness in such acid urine, I have since executed a third series of experiments in which the inoculating material was similar to that of A in the fact that it swarmed with Bacillus spores, only it was composed of hay-infusion instead of urine, in which the organisms had gone on to spore-formation. The results were, however, in no way different. Out of 24 trials, fermentation did

* From a burette-tube kept for such fluids.

† The boiling in the can was adopted because the heat in this way is more constant and not subject to the continuance of those elevations which are so liable to occur in boiling over the flame (see p. 23).

not take place in a single instance, the inoculated mixture having been boiled as before for ten minutes.

Further than this I have not gone, at present, though it will be easy, when time permits, to ascertain the exact death-point of the Bacillus-spores, and whether their power of resistance is at all greater than that of the rods and filaments from which they are derived. Had it been found in the foregoing experiments that fermentation invariably occurred in the fluids in which the spores were contained and not in those holding the rods and filaments, we should have had a fair presumption that the spores had survived—since, in face of the possibility of the existence of a chemical ferment in the materials which served as inoculating agents, this would probably have been similar in both. Still this view could not have been certainly held; the differences in the medium which had led to spore-formation in the one and not in the other liquid *might* also have entailed a difference in their chemical products; so that, in the face of affirmative results, the possible influence of the medium and its chemical principles must have been differentiated from the influence of the organism alone.

It remained only to ascertain by similarly exact experiments whether any evidence could be obtained in favour of the statement that a previous desiccation enabled spores, in such a state, and when surrounded by thin albuminoid or gelatinous envelopes, to resist for a long time the moistening influence of water, and thereby to withstand for prolonged periods a degree of heat which would otherwise have proved destructive.

To test this point I proceeded in the following manner. I took a hay-infusion on which there was a well-formed scum containing myriads of the most typical spore-bearing fibres, partly entire and partly breaking up. This was put into a corked vessel and shaken vigorously for a few minutes, so as to procure a uniform dissemination of the spores through the liquid. Some of the thick, muddy-looking fluid was then poured upon an ordinary, clean, microscope slip, so as to cover it with a stratum of fluid, which was subsequently allowed to evaporate. In the course of three or four hours, when a dry opaque layer had been left upon the glass, the slip was placed in the dry chamber of an incubator at a temperature of 122° F., where it was kept exactly four days. The dry layer was then scraped off with a clean knife into a clean watch-glass, and to the resulting powdery material about thirty or forty drops of distilled water were added.

After allowing the powder to remain thus immersed for four hours, so as to imitate the stage of preparation of a hay-infusion, some of the stirred-up mixture was added to a quantity of urine having an acidity equivalent to eleven minims of liquor potassæ per ounce (about $2\frac{1}{2}$ per cent.) and a specific gravity of 1023. The addition was made in the proportion of two minims of the spore-containing liquid to each ounce of the urine, and with this well-shaken mixture nine bulb-tubes were charged. After their necks had been drawn out, the fluid in each of them was boiled over the flame for rather less than one minute, when the vessel was hermetically sealed. An interval of one minute having been allowed to elapse, each closed vessel was inverted and plunged into a vessel of boiling water for twenty minutes. Subsequently all were placed together in an incubator at a temperature of 122° F., and with them a control experiment in which some of the same urine had been boiled alone for twenty minutes in a small flask plugged with cotton-wool, and to which some drops of the original spore-containing mixture (not previously dried or heated) were added, in the above-mentioned proportion, when the urine was cool. This latter operation was effected by removing the cotton-wool plug for an instant, allowing the spore-containing fluid to drop into the urine, and then carefully replacing the plug, after the manner so often adopted by Professor Lister*.

The result of these experiments was as follows:—In sixteen hours the fluid in the control experiment was notably turbid, and a thin scum had formed on the surface at the expiration of 24 hours. The other nine fluids all remained quite clear, and showed no signs of turbidity during the ten days that they were retained in the incubator.

It did not seem necessary to go any further for the present, and neither did time permit of it. Enough had been done to show how little exact experiment would give any countenance to the hypotheses and wild assumptions which have of late been so rife in regard to the powers of endurance of Bacilli-spores—hypotheses and assumptions which seemed to their authors necessary, in face of the now-admitted fact that a hay-infusion will often ferment after it has been boiled even for several hours.

* Quart. Journ. of Microsc. Science, 1873, p. 384.

IX. *Bearing of the Experimental Evidence upon the Germ Theory of Disease.*

Though it may be conceded that with our present state of knowledge an affirmative decision in regard to the absolute proof of the present occurrence of Archebiosis may be still withheld, there is, I think, no similar warrant for suspense of judgment in regard to the Germ Theory of Disease or, as it is also called, the doctrine of Contagium Vivum. Existing evidence seems to me abundantly sufficient for the rejection of this doctrine as untrue *.

My urine and potash experiments will go far to illustrate this difference in the weight of the evidence in regard to the two questions.

A "sterilized" fluid—that is, one which left to itself would always remain pure—may be caused to ferment by the addition of a certain proportion of liquor potassæ devoid of all living things, especially if the influence of the potash be favoured by certain accessory physical conditions. This fact is admitted by M. Pasteur himself †. During the fermentation thus initiated, a matter (ferment) appears and increases, which is capable of spreading a similar process far and wide in suitable media.

But, on the strength of the analogy upon which the germ-theorists rely, we may find in such an experiment a warrant for the belief that in a healthy person, free from the contagium of typhoid fever or any other of its class, certain kinds of ingesta (solids or fluids), wholly free from all specific poison may,

* Since this paper was read, the doctrine has again been proclaimed—and never with more force and ability—by Dr. William Roberts (Brit. Med. Journal, Aug. 11, 1877). Its essential points may be stated in the words of its latest exponent. He says:—"I have already directed your attention to the analogy between the action of an organised ferment and a contagious fever. The analogy is probably real, in so far, at least, that it leads us to the inference that contagium, like a ferment, is something that is alive. . . . If, then, the doctrine of a contagium vivum be true, we are almost forced to the conclusion that contagium consists (at least in the immense majority of cases) of an independent organism or parasite; and it is in this sense alone that I shall consider the doctrine, ... it is more than probable, looking to the general analogy between them, that all infective diseases conform in some fashion to one fundamental type. If septic Bacteria are the cause of septicæmia, if the Spirilla are the cause of relapsing fever, if the *Bacillus anthracis* is the cause of splenic fever, the inference is almost irresistible that other analogous organisms are the cause of other infective inflammations and of other specific fevers."—*Sept.* 1877.

† See p. 31, note †.

with or without the favouring influence of other altered conditions, give rise to an independent zymotic process. And during the process thus initiated, a matter (contagium) appears and increases in certain of the fluids or tissues of the body, which is capable of spreading a similar disease far and wide amongst receptive members of the community.

Can the germless liquor potassæ plus the favouring conditions (the principal of which is a certain high temperature) be regarded as the "cause" of the fermentation? The answer does not admit of doubt: the effect in question would not have taken place without their influence. The old logical formula in regard to the word, *cessante causá cessat et effectus*, completely justifies this point of view; and so also does the definition of Sir John Herschel. A "cause," said this philosopher, is "an assemblage of phenomena which occurring, *some other* phenomenon invariably commences or has its origin."

But there is a point of view which must not be lost sight of. It is of considerable importance, and has of late been dwelt upon by G. H. Lewes with his usual force and clearness. He says*:—"The fact that it is a convenience to select some one element out of the group, either for its conspicuousness, its novelty, or its interest, and that we call it the cause of the change, throwing all the other elements into the background of *conditions*, must not make us overlook the fact that this cause—this selected condition—is only effective in coalescence with the others. Every condition is causal; the effect is but the sum of the conditions."

This brings us to the only point of doubt which can possibly exist in regard to the interpretation of my experiment†. It is whether our most prominent causal element, the liquor potassæ, exercises its influence (*a*) partly upon the fluid and partly upon certain otherwise dead or impotent germs still lurking within the vessel, or (*b*) simply upon the mere chemical constituents of the fluid medium, but in such a way as actually to engender minute particles of living matter which thereafter appear as ferment-organisms.

If a practically dead germ can by any treatment be revived, it may take its place as one of the causal conditions leading to fermentation; hence it is that a certain reserve may still be maintained as regards the absolute proof of the possibility of a germless origin of common fermentations, and the almost simultaneous occurrence of a new birth of living units (Archebiosis).

* 'Problems of Life and Mind,' vol. ii. p. 390. † See p. 47.

But all similar grounds for reserve are absent—are non-existent, in fact—in regard to the bearing of this experiment upon the possibility of an occasional independent origin for zymotic disease, whether or not such disease is characterized by the appearance within the body of any distinctive living organisms *.

This I will now endeavour to demonstrate.

It is the process of fermentation which is supposed to be in part analogous to the zymotic disease. It is true that a contagious something becomes engendered during fermentation and during zymosis, by means of which the process or the disease may be spread abroad. But there are important differences in regard to the possible independent origin of the two processes which have hitherto been only too much neglected. The treatment of this subject has often been much too superficial. In order to produce a kind of pictorial effect which may easily captivate the imagination, difficulties are often ignored, and many new, modifying, or antagonistic points of view have even of late been treated as though they were non-existent.

A few words will suffice to make plain some of the differences between the respective conditions which would be operative in the germless origin of fermentation on the one hand, and in the *de novo* origin of a contagious disease on the other. And in so doing I shall be able, I think, at the same time, to show how much simpler it would be to bring about an independent zymosis than an independent fermentation—that is, if we are to rely on the analogy upon which the germ-theorists base their arguments.

During the great majority of fermentations living organisms make their appearance and rapidly multiply. These living organisms have been proved to be common producers of chemical principles, some of which are soluble ferments, others (like pyrogen) are poisons which may be almost as deadly as that of a serpent, whilst others still are inert and appear as mere pigment-granules. It is proved that some of these chemical principles act as true ferments †. It is thought, and it is probable, that the organisms themselves—altogether apart from their media and what else they may contain—may be capable of doing the same. Still this has not yet been definitely proved; so that the action of soluble

* The rule is, that organisms are present in fermentations, whilst they are, so far as we know, quite exceptional in zymotic diseases.

† Pasteur, 'Compt. Rend.' July 3, 1876, p. 4.

chemical ferments is at present almost better substantiated than that of the living organisms by which they may have been formed. By means of boiling alcohol and other agents these bodies can be isolated and freed from living impurity. It is, however, much more difficult entirely to separate minute living organisms from their media *, and consequently more difficult to be perfectly certain in regard to their potencies. It is, however, on account of the derivation of the chemical ferments from the living units, and because of the presence of these latter bodies in all fermenting mixtures, that their own agency is still regarded by many as essential to the initiation of ordinary fermentations. But, as I have already indicated, we much need further information as to the precise mode in which fermentation is initiated and carried on by soluble ferments like that which M. Musculus discovered in and separated from urine. If they (all or any of them) are capable of setting up fermentations in germless fluids in the course of which organisms appear, such phenomena would most effectually disprove an exclusive germ theory.

Turning now to the process of zymosis, we find the available generative conditions altogether different. Here we have to do not with fluids only, but with tissues and organs composed of living elements characterized by all kinds and degrees of activity. Some of them produce the various soluble ferments of the body, some may produce poisons, and others habitually lead to the formation of pigment-granules—vital acts severally similar in kind to those which the common ferment-organisms are known to manifest. Tissue-elements without number having such and multitudes of other properties are therefore ever present, capable under certain influences of being more or less easily diverted into unhealthy modes of action, so that many of them may become true living ferments in the modern sense of that term †, and therefore possible producers of chemical ferments (contagia) capable of

* The more efficient means of filtering organisms from their media, which we now possess, by means of porous earthenware, ought to be useful in this direction. Such organisms and their germs might be subsequently washed with several distilled waters, just as a chemist would wash a delicate precipitate. It would be strange, indeed, if this very mild usage interfered with the properties of organisms which at other times are credited with such remarkable powers of endurance.

† How legitimate this statement is may be seen from what M. Pasteur himself says. These are his most mature views :—“ I have been gradually led to look upon fermentation as a necessary consequence of the manifestation of life, when that life takes place without the direct combustion due to free oxygen. . . . We

initiating some or the whole of the series of changes by which they were themselves produced, in other suitable sites.

The essential difference between the two problems thus becomes plain. The only point which my experiment leaves in the least doubtful in regard to the causal conditions initiating fermentation is, whether any latent, powerless, and, as it were, dead organized ferment may still, in spite of the usual evidence to the contrary, lurk in the seemingly "sterilized" fluid. This, however, is the very point about which there is no shadow of doubt in regard to zymosis. Possible ferments without number are, by necessity, present in the form of tissue-elements. So that if we are to be guided by the analogy upon which all germ-theorists so strongly rely, the independent generation of a zymotic process should, for the reason above specified, be incomparably more easy to be brought about than fermentation in a germless fluid. In regard to the independent origin of a zymosis, the all-important point is, not whether latent ferments exist, but whether any causes, or sets of unhygienic conditions, can rouse or modify, in certain special modes, the activity of any of these myriads of potential ferments of which the human organism is so largely composed. And if, as some germ-theorists would have us believe, impotent germs of common ferment-organisms, incapable of exclusion, are also widely disseminated throughout the body, these, if they are such unavoidable elements, could (in regard to the ætiology of disease) only be looked upon as components of the body, ranking side by side with the tissue-elements themselves.

Thus such organized ferments or germs as are possibly absent from the "sterilized" experimental fluids are confessedly present by myriads in persons who may be sickening under the influence of various unhygienic conditions or non-specific states of the system; and the only point which is regarded as doubtful in connexion with the *de novo* origin of a zymosis is what analogy might lead us to affirm as completely proved by my experiments, viz., that certain conditions, or states of system, may be capable of rousing some

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may partially see, as a consequence of this theory, that every being, every organ, every cell which lives or continues its life without making use of atmospheric air, or which uses it in a manner insufficient for the whole of the phenomena of its own nutrition, must possess the characteristics of a ferment with regard to the substance which is the source of its total or complementary heat."—*Compt. Rend.* 1872, t. lxxv. p. 784.

of such ferments into a specific kind of activity, wholly apart from the influence of any specific contagia coming from without*.

Even if independent ferment-organisms of common or special kinds do make their appearance during any process of zymosis originated in the manner above suggested, they would, from the point of view of the ætiology of disease, be just as much consequences of the morbific influences, as proliferation of tissue-elements is a consequence of the direct application of acetic acid or any other irritant.

But here, in order to make this point of view more plain, a short digression is necessary.

The intracellular fermentation in vegetal tissues supplies us with a kind of link between the ordinary processes of fermentation and the zymotic processes of animals. MM. Lechartier and Bellamy, as well as Pasteur and others, have now clearly shown that in vegetal tissues placed under certain abnormal or unhealthy conditions, fermentative phenomena take place essentially similar to those occurring in solutions containing independent ferment-organisms. And just as the vegetal cell can do what, in other

* Whilst the last sheets of this paper are passing through the press, a very interesting address by Dr. B. W. Richardson, F.R.S., has been published ('Nature,' Oct. 4, 1877), entitled "A Theory as to the Natural or Glandular Origin of the Contagious Diseases." In it the author advances many strong arguments against the germ theory; he also propounds some interesting speculations as to the mode of origin and action of the chemical principles, or poisons, which constitute, as he believes, the "contagia" of the communicable diseases. Some such views make a very fitting supplement to the doctrines which I have been here attempting to establish in regard to these diseases; only we must, as Dr. Richardson observes, seek gradually to put well-proven facts in the places now occupied by mere speculations. In regard to the practical aspects of the two opposite doctrines, Dr. Richardson makes some very pertinent observations. "If the contagium vivum view be true," he says, "if the air around us is charged with invisible germs, which come from whence we know not, which have unlimited power to fertilize, which need never cease to fertilize and multiply, what hope is there for the skill of man to overcome these hidden foes? Why on some occasion may not a plague spread over the whole world, and destroy its life universally? Whilst, on the other hand, if the opposite notion be true, we have complete mastery over the diffusion of the poisons of all the communicable diseases. We have but to keep steadily in view that the producing and the reproducing power is in the affected body, and we can, even with our present knowledge, all but completely limit the action to the propagating power of that body—its power, I mean, of secretion and diffusion of secretion."—*Oct.* 6, 1877.

cases, the independent organism does, so it is supposed that in the process of zymosis tissue-elements may take on a specifically faulty action, leading to the formation of certain chemical principles or "contagia" in the fluids or tissues of the animal body; so that, in the great majority of zymotic diseases, offcast particles from the body, whether living or dead, when saturated with such principles, may constitute the veritable contagia by which the specific disease is spread abroad amongst the community.

In the majority of the cases of intracellular fermentation no independent organisms are generated, though in others, as in that of the beetroot and the potato, they are invariable concomitants. Similarly in the majority of zymotic diseases no independent organisms are generated, though in others, such as relapsing fever and splenic fever, they are invariable concomitants; and being engendered in diseased parts and fluids they may thereafter themselves act either as real contagia or as carriers of contagion.

The causal conditions capable of inducing fermentation in the beetroot and the potato, and with it the appearance of Bacteria in swarms throughout their tissues, are known, and have no ordinary connexion with preexisting Bacteria. And similarly the causal conditions capable of inducing relapsing fever and splenic fever, though not so definitely known, may nevertheless have no ordinary connexion with preexisting Spirilla and Bacilli resembling those which appear in the blood or tissues of the patients suffering from either of these diseases.

Thus the mere fact that in certain zymotic diseases living organisms have been proved to appear, affords of itself no support whatever to an exclusive germ theory, as I shall, after this digression, endeavour to show.

The fact may be quite otherwise explained, either (1) in accordance with the views of certain germ-theorists, though these are in direct opposition to the statements of others of the same party; (2) in accordance with the statements of this second section of the germ-theorists, supplemented by a belief in heterogenesis.

(1) The presence of latent germs of common though modifiable ferment-organisms throughout the body is invoked by one section of the germ-theorists, who contend that certain altered states of health, together with altered vitality of tissues, may rouse such hitherto latent common organisms into activity, and occasionally convert them into so-called "specific" forms capable of new actions. But based as this view is upon wholly insufficient evidence, and

with its fundamental position denied by other leading germ-theorists, it would, even had it been securely founded, be quite inadequate to meet the necessities of their position. A special zymotic disease, which had arisen in the manner above indicated, would assuredly have had what is termed a *de novo* origin—it would have started from no specific cause, and would never have developed, but for the existence of those "determining conditions" which brought about the altered state of health and tissues. This group of conditions would therefore constitute the cause of the disease; and inasmuch as, by the hypothesis we are now considering, the common germs are held to be *ever present and unavoidable*, any changes or developments which they might take on could only be studied in the same rank and side by side with those of the other tissue-elements—that is, as consequences or phenomena of the disease.

(2) It was originally affirmed by Prof. Burdon Sanderson *, and it has of late been distinctly reasserted by M. Pasteur †, that the blood and internal tissues of healthy animals and of man are entirely free from ferment-organisms or their germs. Some have sought to modify this view, on the strength of certain experiments which are so extremely inconclusive as to make it almost puerile to have brought them forward ‡.

For, however strong the evidence is that living units may, on certain occasions, be even proved experimentally to appear in fluids in which no living matter previously existed (archebiosis), it is even stronger to show that, under certain conditions, similar low, independent forms of life may originate in the midst of living tissues previously free from them, by a kind of transformation

* Thirteenth Report of the Medical Officer of the Privy Council.

† Comptes Rendus, April 30, 1877, p. 900.

‡ Cutting out portions of the internal organs of recently killed animals, enveloping them with superheated paraffine, and then placing them in an incubator at a suitable temperature to see whether germs and organisms will appear, would, even if taken alone, obviously permit no certain conclusion to be drawn from their appearance. But the evidence relied upon by Sanderson and Pasteur tends as strongly to show that they are not developments of preexisting germs, as certain other evidence subsequently to be mentioned tends to show that they are heterogenetic products (Trans. of Path. Soc. 1875, p. 267). Yet, following a now long-established custom of ignoring the possibility of the heterogenetic origin of Bacteria, the results of such experiments are by some supposed to demonstrate the existence of latent germs in an organ like the spleen, for instance, which is wholly cut off from outside communication—and even when the blood itself is declared to be germless.

(heterogenesis) of some of the units of protoplasm, which though still living, have been modified in nature and tendency by reason of their existence in a partially devitalized area.

The evidence in favour of this last kind of change may be regarded wholly apart from that furnished by the closed-flask experiments, from which it is quite distinct. It suffices, I think, to account for the presence of organisms in some of those local and general diseases with which they are known to be associated, and therefore to complete the proof that even such disease may originate *de novo* (as well as by contagion), and that the organisms which characterize them are, in such cases, consequences or concomitant products, not causes of the local or general conditions at whose bidding they appear. The elements of the proof are these:—

(*a*) First there is the evidence which has been adduced by various observers as a result of the study by the microscope of the mode in which organisms appear within tissue-elements. I do not lay much stress upon this here, because evidence of such a nature is more open to various objections than that which is to follow*.

(*b*) Although the blood and internal tissues of healthy animals and of man are free from independent organisms and their germs, yet such organisms will habitually show themselves after death, in the course of a few days, throughout all the organs of one of the lower animals or of man—even when life has been abruptly terminated during a state of health. It cannot be said, in explanation of this, that the organisms naturally present in the intestinal canal have been enabled to spread through the body so as to reach its inmost recesses *after death*—since many of the organisms found are motionless, and others have mere to-and-fro movements of a non-progressive character. The blood, again, has ceased to circulate, so that this fluid, germless during life, cannot after death be considered to act even as a carrier. If the organisms themselves cannot make their way through the tissues, and if no carrier exist, they must naturally have been born in or near the sites in which they are found.

Phenomena of this kind are to be witnessed even in insects, such as silkworms and flies; and the organisms that habitually develope in them after death are, as in the case of higher animals, just such organisms as appear in some of their best-known contagious diseases†. Certain of these diseases, like "muscardine,"

* On this subject see 'Beginnings of Life,' vol. ii. p. 342.

† Ibid. pp. 327, note 1, and 330, and Trans. of the Patholog. Soc. 1875, p. 343.

seem to be generable *de novo* at the will of the operator by merely placing the animal for a few days under particular sets of unhealthy conditions.

(*c*) Some of the ferment-organisms may also be made to appear at will in certain parts of still living and previously healthy animals by determining in any such part either (1) a greatly lowered vital activity, or (2) an active perversion of the nutritive life of the part of considerable intensity.

1. This subject has been studied experimentally by Messrs. Lewis and Cunningham *, two thoroughly competent and trustworthy observers, whose researches during recent years have won for them a deservedly high reputation. They say, "The object of the experiments was to ascertain whether, by interfering with the vascular supply of certain tissues and organs of the body of an animal without injuring the isolated tissue, we should be able within the course of some hours to detect organisms in those parts in the same manner as we had been able to do when an animal had been killed under chloroform and set aside in a warm place. We found that such was the result, and that a kidney, for example, when [its artery was] carefully ligatured without interfering with its position in the abdomen, would be found after some hours to contain precisely similar organisms; whereas the other kidney, whose circulation had not been interfered with, contained no trace of any vegetation whatever" †.

* 'The Fungus-Disease of India,' Calcutta, 1875, p. 89.

† On September 17, 1877, I had an opportunity of seeing how far this would hold good for the human subject. On that day I made an examination, 12 hours after death, of the body of a young man who had been suffering from severe heart-disease in University College Hospital. His temperature had only been slightly raised for about 48 hours before death; but there was reason for believing that embolic obstructions had recently occurred in one or both kidneys. Abundant "vegetations" were found on the mitral and aortic valves, and two or three embolic patches existed in each kidney, some being recent and others of older date. One large yellowish embolic patch was likewise found occupying the upper extremity of an enlarged spleen. Some blood from the right ventricle and some urine from the bladder, carefully removed with capillary tubes, on examination with the microscope and a $\frac{1}{12}$ object-glass, showed no organisms of any kind. Portions of tissue cut from the interior of the liver also showed no organisms. On the other hand, the embolic patch in the spleen as well as those in the kidney, both old and recent, showed, when portions of their disintegrated substance were examined, organisms, more or less abundantly distributed, similar to those which Messrs. Cunningham and Lewis have figured. Some were Bacilli and some were more like what Cohn now distin-

2. Facts of this second order have been thoroughly established by the important researches of Professor Burdon Sanderson. He says*:—"If a few drops of previously boiled and cooled dilute solution of ammonia are injected underneath the skin of a guinea-pig, a diffuse inflammation is produced, the exudation liquid of which is found after twenty-four hours to be charged with Bacteria." "Other chemical agents," he adds, "will lead to the same results, and always under conditions which preclude the possibility of the introduction of any infecting matter from without."

Elsewhere† the same investigator refers to experiments which were made about the same time in order to throw light upon the cause of the appearance of Bacteria in certain peritoneal exudations, and to ascertain whether or not their presence was to be considered as "a mere result of the intensity of the peritonitis." He says:—"To determine this experiments were made during the following month (May 1871), which consisted in inducing intense peritonitis by the injection, not of exudation liquids, but of chemical irritants, particularly dilute ammonia and concentrated solution of iodine in hydriodic acid. As regards the ammonia, precautions were taken to guard against contamination by boiling and cooling the liquids as well as the implements to be used immediately before injection. In the case of the iodine solution this was, of course, unnecessary. In every instance it was found that the exudation liquids, collected from twenty-four to forty-eight hours after injection, were charged with Bacteria, whence it appeared probable that the existence of these organisms was dependent, not on the nature of the exciting liquid by which the inflammation was induced, but on the intensity of the inflammation itself."

From the various evidence more or less fully referred to in the present section it seems to me legitimate to conclude:—

First, that if we are to be guided by the analogy now dwelt upon as existing between fermentation and zymosis, it would be per-

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guishes as Vibriones. They were not so abundant as to be always found without careful examination; and, on the other hand, in the diseased splenic tissue there were a multitude of small acicular crystals which an inexperienced observer might mistake for motionless organisms. In the lower healthy portion of the spleen no organisms were found.

* Transactions of the Patholog. Soc. 1872, p. 306–308.

† Reports of the Med. Officer of the Privy Council, &c., New S., No. vi., 1875, p. 57.

fectly certain that the latter process can originate *de novo*—that is, under the influence of certain general or special conditions, and where specific contagia of any kind are at first absent though they subsequently appear as results or concomitant products. So that an exclusive theory of "contagion," as the only present cause of communicable diseases, is not supported by experimental evidence.

Secondly, that some contagia are mere not-living chemical principles, though others may be living units.

Thirdly, that even in the latter case, if the primary contagious action be really due to the living units and not to the media in which they are found, such primary action is probably dependent rather upon the chemical changes or "contact actions" which they are capable of setting up than upon their mere growth and vegetative multiplication.

Fourthly, that where we have to do with a true living contagium (whether pus-corpuscle or ferment-organism), the primary changes which it incites are probably of a nature to engender (either in the fluids or from the tissue-elements of the part) bodies similar to itself, so that the infected part speedily swarms therewith. When pus from a certain focus of inflammation comes into contact with a healthy conjunctiva, and therein excites a contagious form of inflammation, no one adopts the absurd notion that all the pus-corpuscles in this second inflammatory focus are the lineal descendants of those which acted as the contagium; and the mode of action may be altogether similar when matter containing Bacilli, by coming into contact with a wounded surface, gives rise to splenic fever and the appearance of such organisms all through the body. The old notion about the excessive self-multiplication of the original contagium is probably altogether erroneous.

Thus all the distinctive positions of those who advocate a belief in the so-called "Germ-theory of Disease," or rely upon the exclusive doctrine of a "Contagium vivum," seem to be absolutely broken down and refuted. We may give that attention to the appearance and development of independent organisms in association with morbid processes which the importance of their presence demands, but we must regard them as concomitant products, and not at all, or except to an extremely limited extent, as causes of those local and general diseases with which they are inseparably linked.

Note on Australian Finches of the Genus *Poëphila*.

By Captain WILLIAM E. ARMIT, F.L.S.

[Read November 1, 1877.*]

AT a meeting of the Queensland Philosophical Society, held in Brisbane on the 10th of August, 1876, Mr. S. Diggles read some "Notes on new and rare Specimens of Australian Birds."

After a few remarks, Mr. Diggles proceeds to correct an error into which he asserts our great author, Mr. Gould, has fallen in relation to a beautiful genus of Finches (*Poëphila*)—one which he (Mr. Gould) had named after his own wife, *P. Gouldiæ*, turning out to be the female of another species, viz. *P. mirabilis*, Hom. & Jacq.

Mr. Diggles adduces the following testimonies in support of this assertion:—

First. The specimens which he had examined were forwarded to him by Mr. Waterhouse, of the Adelaide Museum, who had received them from Mr. Stapleton, the latter gentleman having procured them at Palmerston, in the Northern territory of South Australia.

Mr. Stapleton thus writes concerning these birds:—"This species (*P. Gouldiæ*, Gould) and *P. mirabilis* are gregarious the most part of the year. They associate in flocks of about equal numbers, live upon the same food, are precisely similar in habits, have the same unmusical note, and agree well together. I am inclined to think they are simply varieties, and that the slight difference in colour is regulated by some law or cause which prevents any further alteration."

Secondly. A gentleman writing from Charters' Towers (near Townsville) mentions its occurrence at that place, but states

* [For the author's interests and the Society's credit it is right to state, that while the former forwarded his MS. at the end of March 1877, it did not reach Burlington House, unfortunately, until the day after the final Meeting, June 1877, and, in consequence, had to lie over until the commencement of the Winter Session, then taking its place in publication according to order. Meanwhile there has appeared a paper in the Proceedings of the Linnean Society of New South Wales, vol. ii. pt. 1, p. 70, "Some further Remarks on *Poëphila Gouldiæ* and *P. mirabilis*, Hom. & Jacq.," by Mr. E. Pierson Ramsay, F.L.S., in which this gentleman discusses the question of their specific distinction, and particularly refers to information received from Captain Armit. The present communication, however, deals with the latter's evidence more fully than that referred to, having precedence of publication for the reasons given.—EDITOR.]

that it is rare, and encloses a newspaper of date 18th March (1876?), from which it appears that it has been reared at that place.

A pair of these *P. Gouldiæ*, which he calls "Variegated Bullfinch," built their nest in the wheel of the whip-pole of the "Martin-Lyons" reef, and became so accustomed to the working of the whip, that they used to perch on the rope when ascending, and on reaching the level of the nest would hop into it. The male and one of the young effected their escape; but the female and six fully fledged young ones were secured and taken to Mr. J. H. Rutherford (since deceased), forming a valuable addition to that gentleman's collection of natural curiosities.

Mr. Rutherford states "that both sexes are alike, but that the male has a red and the female a black head, the plumage of the young birds being a sober drab."

Thirdly. That the late Mr. Coxen was also of his (Mr. Diggles's) opinion.

Now Mr. Diggles brings forward no proof of the Palmerston specimens having been sexed by dissection, which is, it will be conceded, the only method to arrive at a definite conclusion in a matter of doubtful sex.

Mr. Rutherford, on the other hand, distinctly states that the male has a red head and the female a black head; and although he had no opportunity of sexing the red-headed bird (which, it is stated, escaped), he seems to have done so in the case of the black-headed bird in his possession; otherwise it is hard to understand how he could arrive at such knowledge.

Mr. Diggles never saw either of the above species in a state of nature, and therefore could not study their nidification or habits.

The following facts will, I think, prove that *P. Gouldiæ* is a distinct species from *P. mirabilis*, breeding true red-headed males in contradistinction to the black-headed ones of the latter.

In January 1876 I shot a female of *P. Gouldiæ* at Dunrobin, near Georgetown. There were only two birds; and, unfortunately, the male (red-headed) escaped. This specimen, which I carefully sexed, I sent to my friend Mr. E. Pierson Ramsay, F.L.S., C.M.Z.S., Curator of the Australian Museum, Sydney, who kindly sent me the names of this species and also of *P. mirabilis*, which were at that time both quite new to me.

In his letter, Mr. Ramsay requested me to look up these species, and, if possible, discover whether they were distinct. I did

not, however, come across any more specimens of either species until the 16th of February last, when I had the good fortune to see a flock of twelve *P. mirabilis* close to the native-police barracks. I secured three males and one female, and could easily have shot every one of the flock; but noticing a female carrying a long piece of dry grass, I at once desisted, being most anxious to watch their nidification and to secure the full-fledged young.

All these birds had black heads, the female being easily distinguishable by the plumage being much less bright than that of the male bird—the line of metallic blue which divides the black from the purple on the throat being clearly defined in the male, whereas in a female now before me the black throat-feathers are continued to the breast, being only tipped with blue, the breast is a pale peach-bloom colour, and not of the same rich plum as that of the male, and, lastly, the elongated central tail-feathers are much shorter in the female. In the specimen now before me these feathers do not exceed the other tail-feathers more than half an inch.

The elongated feathers of three males now before me measure respectively $2\frac{1}{2}$, $2\frac{3}{8}$, and $2\frac{3}{4}$ inches in length. The two central tail-feathers of my female specimen measure $1\frac{7}{8}$ inch in length. The two outer tail-feathers, one on each side of the elongated ones, have the shafts slightly lengthened, $\frac{1}{8}$ of an inch.

I have five male specimens of *P. Gouldiæ* before me at this moment, all of which were shot by myself since the 16th of February last.

None of this series differ in even the slighest degree in colouring, and only very little in the length of the central tail-feathers. The length of these is as follows:—No. 1, $2\frac{1}{8}$ inches; No. 2, $2\frac{3}{4}$ inches; No. 3, $2\frac{1}{8}$ inches; No. 4, $2\frac{1}{16}$ inches; No. 5, $1\frac{1}{2}$ inch (not in full plumage). Two females:—No. 1, 2 inches; No. 2, 2 inches.

I find, on comparing the females of both species together, that the blue line between the black feathers of the throat and the pale peach-bloom ones of the breast is more distinct in *P. Gouldiæ* than in *P. mirabilis*; and, if possible, *P. Gouldiæ* is a less highly coloured bird than *P. mirabilis*. Mr. Gould omitted the long central tail-feathers in his *P. Gouldiæ*, which, however, are constant. The next two feathers from the two central ones in *P. Gouldiæ* have not the shafts quite so much elongated as in *P. mirabilis* in my specimens.

I have thus distinct evidence of sex in five specimens (♂) of *P.*

mirabilis and three females (♀), having sent two males and two females to Mr. Ramsay, of Sydney, and Mr. T. A. Gulliver, Normanton.

In every one of the above cases the males had a black head.

Of *P. Gouldiæ* I have five red-headed birds, all of which I have proved, by dissection, to be males, and two females having black heads, also similarly sexed.

I regret that I have been unable to discover a nest of either of these lovely little birds, although I have devoted much time in searching for them. I still hope, however, to be able to secure young full-fledged birds and to rear them to naturity, and thus solve this point.

From the evidence which I have now laid before you I think you will agree with me that *Poëphila Gouldiæ* is a distinct species from *Poëphila mirabilis*, and that Mr. Diggles's theory "that the red-headed bird is the female of *P. mirabilis*" must fall to the ground, being incorrect. I hope, ere long, to be able to send the Society more evidence on the subject.

Report on the Insecta (including *Arachnida*) collected by Captain Feilden and Mr. Hart between the Parallels of 78° and 83° North Latitude, during the recent Arctic Expedition. By Robert M'Lachlan, F.R.S., F.L.S., &c.

[Read November 15, 1877.]

This paper concerns the Arthropoda (excluding Crustacea*) of the Voyage of the 'Alert' and 'Discovery' towards the North Pole in the years 1875–1876. The collections were chiefly formed by Capt. H. W. Feilden, R.A., who was attached to the 'Alert' as naturalist; but several interesting contributions resulted from the researches of Mr. Hart, who occupied a similar position on board the 'Discovery.' Neither of these gentlemen was an entomologist. Capt. Feilden had already made for himself a reputation as an ornithologist; Mr. Hart is specially a botanist. The latter could scarcely have been expected to form any extensive zoological collections, a province that more especially pertained to his colleague; and I am sure all will agree that the duties could

* A Report on the Crustacea collected by the Expedition, by Mr. E. J. Miers, of the British Museum, has appeared in the 'Annals and Magazine of Natural History,' ser. 4, vol. xx. pp. 52–66, 96–110 (1877).

not have been better performed. I think also that Capt. Feilden's botanical collections proved of no mean importance.

In stating that neither of the naturalists was an entomologist I do so in no apologetic spirit. On the contrary, I believe that under scarcely any circumstances would it have been possible for a more complete collection of insects to have been made; and when I presently enter into some details, the justice of this remark will become apparent. If we take into consideration the conditions under which these two gentlemen worked, the amount of materials is surprising. We will concede that the chase after a butterfly or a bee in the Arctic regions may be looked upon as a heat-producing exhilarating pursuit; on the other hand, it must be remembered that a very considerable portion of the collection consists of forms that require searching for under the snow or half-frozen earth, and amongst moss and dwarf herbage, necessitating a prostrate position tending to the rapid elimination of heat, and which, if long continued, must detract very strongly from the comfort of the collector.

When Capt. Feilden (at the suggestion of the Council of the Royal Society) did me the honour to ask me to work out the Insecta, I consented after much hesitation. It is probable that it was expected *all* would receive attention from me personally. But it became necessary to point out that this could not be done by one alone. Entomology has become a subject more extensive than all the other branches of zoological science combined; and by the Arachnida being included it was here extended almost beyond its broadest limits: it was necessary, therefore, to explain that the assistance of specialists must be sought. Acting upon this, the Spiders were placed in the hands of the Rev. O. Pickard Cambridge, our best authority; the Acari have received the attention of Mr. Andrew Murray *, who has recently paid considerable attention to the group; and I was fortunate in obtaining the opinion of Baron von Osten-Sacken upon the rather numerous and especially difficult Diptera †. The remaining orders have (with occasional help) been attended to by myself.

Capt. Feilden especially desired that this Report should refer only to materials collected from the parallel of 78° northward—in

* Unfortunately this assertion proved almost premature; see the remarks on p. 121.

† Baron von Osten-Sacken has also reported upon the Diptera collected by the American 'Polaris' Expedition (*vide* 'Proc. Bost. Soc. Nat. History,' xix. pp. 41–43, 1877).

other words, that it might show the results of an examination of the Insect fauna of Grinnell-Land. This was not difficult; for the materials collected south of 78° were few and of little special interest. I think Capt. Feilden acted wisely in this. The fauna of the west coast of Greenland, at any rate as far north as Disco

SKETCH MAP * showing route of the late Arctic Expedition, and general configuration of Grinnell-Land and opposite shores of Greenland between the parallels 78°–83° N. lat., viz. limits of the collecting district herein described.

* Through the kindness and liberality of Mr. N. M'Coll and the proprietors of the 'Athenæum,' the use of this wood-block has been obtained for the Society.—ED.

Island, is already tolerably well-known. So long ago as 1780 the Danish missionary Otto Fabricius published his 'Fauna Grœnlandica;' more recently, in 1859, Schiödte gave an enumeration of the insects of Greenland in Rink's 'Grönland geographisk og statistisk beskrevet;' and only three years ago the species found in East Greenland received attention in the Report of the second German North-Polar voyage. I have not yet seen a connected Report on the collections formed by the naturalist of the American 'Polaris' expedition: these are from a latitude little inferior to that reached by our own expedition; but they still refer to Greenland on the eastern side of Smith Sound.

It was scarcely to be hoped that the insects from a point so far north as between the parallels of 78° and 83° could be of any great importance. The sequel has, on the contrary, proved to my mind incontestably that the most valuable of the whole zoological collections are the Insecta. The Birds may be looked upon as more or less migratory, seeking high latitudes during the short summer and then retiring southward. The Fishes (excepting the lacustrine), Crustacea, Mollusca, &c. are not subject to the rigid conditions imposed upon the Insects; and of these latter it may, I think, be taken for granted that all (excepting the bird-lice, &c., which are carried hither and thither by their hosts) breed and live continuously in these desolate regions. I have used the term desolate; but the desolation is not of that extreme nature one would expect. I am informed by Professor Oliver that over sixty species of flowering plants have been determined in the collections formed by the naturalists of the expedition between the already given parallels of latitude. This fact at first sight reads more like romance; it is strengthened by another, still more remarkable. Thirty-five specimens of gaily-coloured Butterflies were procured, belonging to certainly five distinct species. It may safely be asserted that there are desert regions in the tropics that would not furnish an equal number. Moreover there are two species of Humble-Bees; and an example of one of these was chased by Capt. Feilden (but not captured) in as far north as lat. 82° 30′.

An analysis of the collections produces the following results:—

Hymenoptera......	5 species	Mallophaga	7 species
Coleoptera	1 „	Collembola.........	3 „
Lepidoptera	13 „		
Diptera ... about	15 „	Araneidea	6 „
Hemiptera	1 „	Acaridea ... about	9 „

In all about 60 species. Schiödte enumerated 80 from Greenland*. Staudinger ('Stettiner entomol. Zeitung,' 1857) found about 312 (excluding Arachnida) in Iceland, of which more than one third were Diptera, and there was no Butterfly.

Carrying the analysis a little more into detail, we find the Hymenoptera represented by two species of *Bombus* and three parasitic forms no doubt infesting the larvæ of Lepidoptera. It appears probable that even in these extreme northern latitudes some of the plants may be dependent upon insects for their fertilization and perpetuation. Capt. Feilden noticed that the *Bombi* especially frequented the flowers of a species of *Pedicularis*; and, according to the researches of Müller ('Befruchtung') and Dr. Ogle ('Popular Science Review,' 1870), the species of this genus are more or less incapable of self-fertilization, or, at any rate there is reason to believe that fertilization is, to a large extent, effected through the agency of insects, and especially of *Bombi*.

The paucity of Coleoptera is somewhat remarkable, the order being represented by only one individual of a common species.

The Lepidoptera form the most striking feature amongst the Insecta, and, I venture to say, also amongst the whole of the zoological collections. It is true that I have been able to find only 13 species; but of these, 5 are showy Butterflies (one of them so protean in aspect that some may incline to the belief that the individuals represent several species) belonging to the genera *Colias*, *Argynnis*, *Chrysophanus*, and *Lycæna*. Butterflies have long been known from the lower portions of Greenland, at any rate as far as Disco Island (69° 30′ N.); the expedition found them at Upernavik (75° N.); they are recorded from East Greenland, collected by the second German Expedition. Former expeditions, in search of a north-west passage, found them spread sparingly over the regions visited by them; but all these localities are in much lower latitudes. Dr. Bessels, of the American 'Polaris' Expedition, obtained two examples of *Argynnis polaris* at Polaris Bay (81° 20′–81° 50′); and this was the first indication of the existence of these insects in extreme high latitudes. But the captures made by Dr. Bessels have been eclipsed, and in a remarkable manner, by the discoveries of Capt. Feilden and Mr. Hart, who brought back from between the parallels of 78° and 83° a collection of butterflies that certainly excited my astonishment as an

* Holmgren, 'Sv. Akad. Handlingar,' viii. (1869), raises the number to 83, and enumerates 64 from Spitzbergen.

entomologist. It would perhaps be rash to assert that any absolutely new species is represented among them; but there are forms so peculiar as to necessitate their description as striking varieties, and to warrant the suspicion that they represent a local insect-fauna; although, before this can be asserted as a fact, it will be necessary that the coast all along the west side of Davis Straits be thoroughly examined. The *Chrysophanus* is perhaps the most remarkable, because it apparently represents a condition of our common *C. phlœas* rather than of its near American relative, *C. americanus.* (The peculiarly boreal or alpine genus *Chionobas* is not in the collection.) When we consider that in Lower Greenland only four species have been discovered, and that in Iceland there are none at all, this result is sufficiently surprising. Their absence from Iceland is somewhat inexplicable; for Dr. Staudinger found 33 species of Lepidoptera (including several minute forms) in that island*. But northern insular faunas appear to be generally poor in Butterflies; and in proof of this, it need only be mentioned that in the British Islands we have but 65 species (and of these, several are more or less casual or sporadic in appearance), whereas Lapland, although so much further north, possesses about 60. The only other especially interesting Lepidopterous insect is *Dasychira grœnlandica,* one of the Bombyces, the hairy larvæ of which were found abundantly, of all sizes up to 1½ inch in length.

Many Lepidopterous larvæ were found in the stomachs of Gulls and Terns; many must fall victims to the attacks of parasitic Hymenoptera and Diptera, which there, as everywhere else, infest them. If we combine these conditions with the struggle for existence that must constantly exist with the elements, it becomes evident that only a small portion can be left to be transformed into the perfect state.

Capt. Feilden, in answer to questions, gave me some valuable and interesting information on the habits of Lepidoptera in these latitudes. He informed me that during the short period when there is practically no night, butterflies are continuously on the wing, supposing the sun's face not to be obscured by clouds or passing snow-showers. Furthermore, he told me that about one month in each year is the longest period in which it is possible

* Four or five species of Butterflies have been recorded from Iceland. No recent visitor to the island has confirmed these reports. Staudinger passed an entire season there in the double capacity of scientific entomologist and collector for sale.

for these insects to appear in the perfect state, and that about six weeks is the limit of time allowed to plant-feeding larvæ, during all the rest of the year the land being under snow and ice. This latter fact is suggestive, as showing the conditions under which the species maintain an existence. We have, however, much yet to learn respecting their life-history. The intense cold is not of great importance. We know already that larvæ may be frozen till they are as brittle as rotten twigs, and still suffer in no way. The principal point may be put as follows:—Is there sufficient time in each year for a larva to hatch from the egg, feed up, and change to chrysalis? The continuous day, no doubt, acts beneficially in this respect on the larvæ of butterflies, such as *Colias* and *Argynnis*, which probably feed only in the day-time; but it must act in the contrary manner on those of *Noctuæ*, &c., which practically feed only at night. Upon reviewing all these conditions, I am disposed to think that more than one year is necessary in most of the species for the undergoing of all their transformations. This indeed is already suspected in certain species that inhabit the boreal and alpine portions of Europe.

The Diptera furnish but few points of special interest. When offal was thrown away, or the carcass of a Musk-ox lay on the ground, "blow-flies" appeared ready to perform the scarcely necessary part of scavengers. The genus *Trichocera*, known with us as the "winter-gnat," appeared after midsummer, the only time it can appear if the genus be allowed to exist at all. Most travellers in high latitudes have complained of the attacks of the myriads of Culicidæ. I am informed that this expedition proved no exception when off the lower portions of the coast of Greenland; but the members of it did not suffer in the extreme north, although Culicidæ were not uncommon.

The few remaining orders of insects offer occasion for no special remarks.

Regarding the collections as a whole, I should say there is evident affinity (in some cases absolute identity) with the fauna of Lapland; but, notwithstanding all that has been urged to the contrary, I incline to the belief in a former extensive circumpolar fauna, of which there now exist but remnants. (I would mention incidentally also that I do not think the two great divisions known as the Palæarctic and Nearctic can be maintained for insects, excepting as terms of convenience.) We know that in Miocene times there existed in the latitudes with which we are now deal-

ing, a flora that must have strongly resembled that now possessed by the southern portions of the United States. This is emphatically shown in the fossil plants collected by Capt. Feilden, and which are now in the hands of Prof. Heer for working out. It is reasonable to suppose that a parallel insect-fauna then existed.

After this, from causes not easy to explain (and it is not necessary here to refer to the various theories advanced in explanation), there came a period of gradual cooling down; and I think all evidence goes to prove that this resulted in the establishment of an arctic or circumpolar fauna. This was probably initiated in the older Pliocene period, and culminated before the establishment of the Glacial epoch, when the mighty masses of ice began to move southward, destroying animal life, or driving what remained of it before them. Again, there came a time when an increasing temperature began to manifest itself. The survivors of the arctic fauna commenced to move northward: a portion of them settled on the tops of high mountains and established the existing alpine fauna; stragglers reached the home of their ancestors in the Arctic regions and became the progenitors of the species now existing there. What is practically this theory was first advanced in 1846 by Edward Forbes, in a paper "On the Geological Relations of the existing Fauna and Flora of the British Isles," published in vol. i. of the 'Memoirs of the Geological Survey of Great Britain.' In one form or other it has since been accepted by Darwin, Lyell, Hooker, and others in England, and by Packard, Grote, and LeConte in America. How far north this fauna may now extend we perhaps never shall know. Sir J. D. Hooker, writing in 1860, expressed an opinion that not far north of 81° would prove to be the limit of flowering plants. The recent expedition found them beyond that limit; and if the coast-line, instead of trending east and west at the highest point reached, had proved to still further extend in a northerly direction, I doubt not that both Phanerogamous plants, and also insects, would have been found.

That both alpine and arctic insects are prone to run into puzzling varieties is known to every entomologist: this is strikingly exhibited in some of the materials now under consideration. If my idea that more than one year is often necessary in these regions for an insect to undergo all its transformations be correct, we have one powerful factor in explaining the causes of variation; and a still more potent one is to be found in the

condition of isolation or segregation that necessarily exists, and which must, in my opinion, result in the production of local forms, which in extreme cases are worthy of the term "species."

In concluding this introductory portion I must express my thanks to Capt. Feilden for the assistance he has rendered me, to those gentlemen who have worked out certain groups, and to the officers of the British Museum for the courtesy exhibited on my various visits to that Institution in order to examine the materials collected by former expeditions, and which will now be augmented by the addition of those enumerated in this Report. With these remarks, I pass on to a detailed examination of the collections*.

HYMENOPTERA.

Apidæ.

Bombus balteatus, *Dahlbom.*

Three ♂, from Hayes Sound (lat. 79°, Aug. 4th, 1875); Port Foulke, July 28th, 1875; and lat. 81° 45′ (*Feilden*).

This (I am informed by Mr. F. Smith, who kindly examined the *Bombi*) is the species described by Curtis in the Appendix to 'Ross's Voyage' as *B. Kirbyellus.* It was also found by the 'Polaris' Expedition. A known Arctic species, occurring also in Lapland.

B. polaris, *Curtis.*

One ♂ from Hayes Sound (*Feilden*). A known Arctic American species †.

Ichneumonidæ.

Ichneumon erythromelas, n. sp.

Black; mesonotum, scutellum, and second abdominal segment bright red. Antennæ very stout, 32-jointed, totally black, with very short yellowish microscopic pubescence. Eyes dark liver-coloured. Head finely sculptured. Mesonotum and scutellum finely punctured; the latter flat, narrower behind than in front, somewhat rounded anteriorly. Metanotum (and the sides of the entire thorax) finely punctured; the areas well defined by narrow raised keels, central area narrower in front than posteriorly.

* A slight sketch of some of the results of the expedition was published by me in the 'Entomologist's Monthly Magazine,' vol. xiii. p. 181 (January 1877). This was drawn up after a hurried glance over the insects of scarcely more than a few minutes' duration, and is very faulty.

† From Disco (*Feilden* and *Hart*) are 5 ♀ and 2 ☿ of *B. hyperboreus*, Schönherr (*B. arcticus*, Kirby, *B. alpinus*, O. Fab. nec L.), which, however, did not appear to occur further north.

Abdomen very short, ovate, finely punctured; basal segment with a small red spot in the middle of the sutural margin; second segment wholly bright red, excepting the narrowly black lateral and posterior margins (beneath it has also a tendency to become reddish), basal foveæ evident, transversely oblong; apical segment with a small greenish-yellow median spot. Legs reddish; coxæ, trochanters, and tibiæ (excepting the extreme tips of these latter) shining black; femora externally with a black line; tarsi blackish externally, excepting the first joint of the intermediate and posterior, which is almost wholly reddish. Wings subhyaline, tinged with smoky brown, paler at the tips; nervures black; stigma blackish, somewhat piceous on its lower edge; areolet distinctly pentagonal. Length 6 millims.; expanse 15 millims.

Two females (one mounted as a microscopic slide) from lat. 82° 29′ (August 8th) and 82° 33′ (June 21st) (*Feilden*); one indicated as found on the surface of the snow at an elevation of 800 feet.

A very striking species, pertaining to Gravenhorst's Section xi.

Cryptus arcticus ?, *Schiödte.*

One ♀ from Rawlings Bay, 21st August (*Feilden*), appears to agree more nearly with this than with any other described species. Already recorded by Schiödte from Greenland.

Proctotrypidæ.

Microgaster, sp.

A mass of yellow cocoons formed by larvæ parasitic upon that of *Dasychira grœnlandica*, from Dobbin Bay, August 14th, 1875 (*Feilden*); but the insects had escaped. Possibly it may have been the species noticed by Packard (American Naturalist, xi. p. 52) as found by Dr. Bessels at Polaris Bay, and described as *M. Hallii.*

COLEOPTERA.

Brachelytra.

Quedius fulgidus, *Erichson.*

One example from Discovery Bay (*Hart*). A very widely distributed species, already recorded from Greenland and the North-American continent, occurring all over Europe, and has been found in the Atlantic islands*.

* There is also an example of *Cryptophagus acutangulus*, Gyllenhal, from Floeberg Beach (*Feilden*); but it was found among rubbish discharged from the 'Alert,' and has no claim to be considered an Arctic insect. I am indebted to Mr. E. C. Rye for the determination of this species.

The insect is variable: the Arctic individual is of the ordinary black British form.

LEPIDOPTERA.

Rhopalocera.

Colias Hecla, *Lefebvre*, var. glacialis.

Agrees with the original description and figure of *Hecla*, and with examples from Lapland, in its general form, breadth of the dark border of the wings, &c.; but differs in its much clearer and paler ground-colour (which may be termed *pale* orange), and in the more conspicuous pale greenish-yellow costal margin of anterior wings. The posterior wings on the underside are more smoky greenish than in those I have seen from Lapland; and in this agree better with Lefebvre's figure; the pale margin is very faintly indicated. In one male the discal spot on the anterior wings is obliterated. Expanse, ♂ 44–48 millims., ♀ 47–51 millims.

Two ♂ and one ♀ from lat. 81° 45′, August 12th, 1876, and one ♀ from Hayes Sound, lat. 79° (*Feilden*), all in the finest possible condition; also a much crippled ♂ just emerged from the chrysalis, from Discovery Bay, July 18th, 1876 (*Hart*).

C. Hecla was originally described as from Iceland; but there is little doubt an error in locality was made, and the type was probably from Greenland. It appears to me that the examples before me from the high north can only with justice be referred to this species; but they form a good local variety, which it is desirable to indicate by name. In the British Museum is a series of individuals from other Arctic voyages, all from considerably lower latitudes, that I think should be likewise referred to *Hecla*; but they vary in the opposite direction to my var. *glacialis*, all being very smoky and dark. It is certainly singular that *glacialis*, although from the extreme north, should be indicated especially by its bright and pale coloration. The two females have an appearance of differing somewhat in form, that from lat. 81° 45′ having the anterior wing apparently more obtuse than in that from Hayes Sound; but there is no other difference.

C. Boothii, Curtis, which has been sometimes associated with *C. Hecla*, is, I am convinced, perfectly distinct therefrom, differing in the very narrow dark border of the wings &c.

ARGYNNIS POLARIS, *Boisduval.*

Six examples. Hayes Sound, lat. 79°, and from lat. 81° 42′ and 81° 52′ (*Feilden*), and Discovery Bay (*Hart*).

These vary very little, and are quite typical. *A. polaris* was the only butterfly obtained in the high north by the American 'Polaris' Expedition.

The species is probably spread over the whole of Arctic America from Labrador northwards; but there appears to be some doubt as to its actual occurrence in the Old World. Judging from the somewhat numerous examples I have seen, it appears to be comparatively the least variable of all the Arctic species of the genus.

A. CHARICLEA, *Schneider.*

Under this head I feel compelled to group 20 examples from various localities, ranging from lat. 79° to 81° 52′ N. (*Feilden* and *Hart*). The places indicated by name are Hayes Sound, Port Foulke, Walrus Island, Franklin-Pierce Bay, Cape Hayes, and Discovery Bay. Never before have I been so perplexed over a series of any insect of which I had made a serious study. Without exaggeration, I may safely say that no two of the twenty individuals are precisely alike; and the extremes present numerous discrepancies. Also I think I may say that not one example precisely resembles the typical *Chariclea* of Northern Europe: but that this latter also is subject to considerable variation is evident; and a comparison of the rather numerous figures of it only added to my perplexity, for no two agree. A visit to the British Museum in order to consult the materials obtained from previous Arctic Expeditions did not in the least help me; for I found just as much uncertainty existing in the arranged collection as in my own mind. The upperside of the insects is subject to great variation, but in a measure that cannot be compared with that presented by the underside of the posterior wings, which is usually considered as furnishing the surest characters in *Argynnis*. I essayed an examination of the anal parts of the males (which I am convinced will often serve to distinguish allied species in Butterflies), but found that it would be necessary to have the insects in a fresh state (or in fluid) if any reliable characters were to be sought in these parts.

It would be utterly useless to attempt to describe the forms; the only thing that could be of service would be to give coloured figures of both sides of nearly every example. Some of them may

perhaps resolve themselves into *arctica* of Zetterstedt and *Boisduvallii* of Duponchel, now both grouped with *Chariclea*. There is, however, one extreme individual that I propose to briefly notice by name.

ARGYNNIS CHARICLEA, var. OBSCURATA.

Wings above smoky greyish-fulvous, the basal portion very densely clothed with long brownish-grey hairs, having a bluish or greenish reflection in certain lights: in the anterior pair the basal third is blackish, the black markings all distinct, the postmedian zigzag line complete and rather broad, the submarginal series of spots very large, the border broad, the fringes dirty cream-colour interrupted with blackish; in the posterior wing more than the basal half is blackish, almost confused with the median band, the submarginal series of spots distinct and ordinary, the border surmounted by a series of triangular spots, fringes as in the anterior but less interrupted. Underside—ground-colour of anterior wings brighter; of the discocellular spots only the angulate one and that at the end are distinct; zigzag band distinct, but narrow; submarginal series of spots very indistinct: in the posterior wings the basal half is dark brown, inclosing the median band of pale spots, which is very broad, all the spots more or less coalescent and dirty cream colour; the outer edge of the dark basal portion margined with a narrow whitish line, the space between this and the border light greyish brown, with scarcely any indication of the submarginal series of spots; border broad, dirty cream-colour, surmounted by triangular dark brown spots. Legs and underside of thorax greyish.

There is one ♀ of this from 81° 42' N. Another specimen in the British Museum from the voyage of the 'Enterprise,' somewhat resembles it, differing principally in the middle spot of the median band of the underside of posterior wings being more produced externally, a point in which great variation is exhibited in all the insects.

In concluding my remarks on the twenty examples referred to *A. Chariclea*, I will only say that, so far as I can see, no two entomologists would probably agree as to the number of so-called species comprised therein, nor do I hope for any immediate settlement of the difficulty. Either there is only one species, or there are several; and in favour of the latter hypothesis it might be argued that we in England have species as closely allied as *A.*

Euphrosyne and *A. Selene*, which we know, from habits, &c., to be perfectly distinct; yet each of these has modified forms in northern and alpine districts.

Chrysophanus phlœas, *Linné*, var. Feildeni.

Differs from typical *phlœas* (and also from *americanus*) in the brilliant copper-colour of the upperside of the anterior wings being much less fiery and more subdued, and with brassy reflection (especially in the ♂), so that the colour might almost be termed brassy rather than coppery; the spots normal in number and position, but smaller; the dark border is narrow and silky greyish black with grey fringe, the dark costal margin scarcely indicated: in the posterior wings the ground is of the same silky greyish black as in the border of the anterior, the pale submarginal band pale orange, with occasionally the faintest indications of bluish spots above it. Beneath, the anterior wings are greyish orange (with the ordinary spots), the border and the posterior wings pale cinereous; on the latter wings the dark dots are very faintly indicated, and there is also only the faintest indication of the red submarginal band. Expanse 28–29 millims.

Three examples (2 ♂, 1 ♀) from lat. 81° 45′ (*Feilden*).

I was at first inclined to place this very distinct variety as a form of *americanus*; but the posterior wings are more tailed than in any examples I have seen of that species, though scarcely so much so as in ordinary *phlœas*. The common origin of both species can scarcely be doubted. No species of *Rumex* was found in these high latitudes; but *Oxyria reniformis* occurred at all the stations, and in all probability serves as the food-plant.

Scudder has recently (Bulletin Buffalo Soc. Nat. Sciences, vol. ii. No. 3) broken up *Chrysophanus* into a multitude of genera in a manner that appears to me likely to add to the perplexity of the student rather than to be of any assistance: *phlœas* and *americanus*, according to his system, fall into the genus *Heodes* (Dalman).

The other Arctic species (*C. Dorcas*, Kirby) differs greatly, and belongs to another group.

Lycæna Aquilo, *Boisduval*.

One ♀ from lat. 81° 45′ (*Feilden*). A known Arctic species, extending from Newfoundland northward. Described by Curtis (in Ross's voyage) as *Polyommatus Franklinii*. Scudder places it and allied species in the genus *Agriades* (Hübner).

Heterocera.

Bombyces.

Dasychira grœnlandica (*Wocke*), *Homeyer*, *Zweite deutsche Nordpolarfahrt*, Bd. ii. Abth. i. p. 409.

One ♂, lat. 82° 30′, July 6th (*Feilden*); also numerous larvæ (in fluid) in various stages of growth from Hayes Sound, Dumb-Bell Lake, Cape Joseph Henry (82° 45′), &c., collected by Capt. Feilden, and some from Discovery Bay by Mr. Hart; cocoons from Hayes Sound, Dobbin Bay, Franklin-Pierce Bay, &c. (from one of these a parasitic dipterous insect of the family Tachinidæ had emerged). The largest larva is fully 1½ inch long. Capt. Feilden informs me that the principal food-plant is *Saxifraga oppositifolia*; but *Salix arctica* is also noted: in all probability the species feeds on a variety of plants. It is in the British Museum from Winter Cove, taken during the voyage of the 'Enterprise.'

It was found by the second German North-Polar expedition in East Greenland.

No doubt it is the insect alluded to by Dr. Packard (American Naturalist, xi. p. 52) as found by the 'Polaris' expedition; and that author gives a description of the eggs, larva, cocoon, &c. He identifies the species as *Laria Rossii*, Curtis, but, I think, in error; and Wocke is also of this opinion. Curtis's insect is no doubt a true *Dasychira*, and allied; but I consider it something unknown to me. *D. grœnlandica* is a smoky-black species, strongly resembling one of the bombyciform Geometridæ of the genus *Biston*: the anterior wings are smoky blackish, subdiaphanous, with strong black neuration and a black crescentiform mark at the end of the cell; the posterior whitish grey, with fuscous neuration, and without the slightest trace of the broad blackish margin so strongly represented in Curtis's figure—thus, as it appears to me, precluding the possibility of the one being a form of the other. The species indicated by Christoph (Stett. ent. Zeit. 1858, p. 310), and Mœschler (*l. c.* 1870, p. 252), from Labrador, is, in all probability, the true *Rossii*.

Noctuæ.

Mamestra (?) Feildeni, n. sp.

Anterior wings rather broad, the costal margin nearly straight, the apical margin oblique, but not strikingly so. The ground-colour may be described as blackish varied with whitish or grey;

the half-line whitish, rather conspicuous; the inner and elbowed lines only indicated as limiting the broad blackish central portion of the wing, the inner line somewhat angulate in the middle; the elbowed line nearly straight from the costa to the elbow, thence continued in a strongly oblique manner to the inner margin, so that the broad central dark portion is nearly twice as broad on the costal as on the inner margin; beyond the elbowed line the ground colour is much paler, greyish varied with black scales, the somewhat curved subterminal line indicated by a series of about six blackish dots; the ordinary spots (or stigmata) conspicuous; the "orbicular" nearly quadrate, with a black spot on its inner side, the "reniform" large, somewhat filled in with greyish; the space between it and the "orbicular" is black, the two spots connected on their lower edges by a whitish line on the nervure; the claviform only slightly indicated; fringe whitish, intersected with blackish. Posterior wings whitish, with a slight creamy tinge; the inner margin suffused with blackish, the outer margin with a very broad blackish border occupying about one fourth of the wing, in which is included a short pale line at the anal angle; central spot very large, black, half-moon-shaped; fringes silky whitish, the hairs on the base of the inner margin blackish. The underside of both pairs of wings nearly uniformly whitish: the anterior slightly suffused with smoky, the subterminal line distinct; a rather conspicuous lunate blackish central spot; fringe wholly whitish; posterior with a very distinct, nearly rounded, black discal spot; the dark border paler and narrower than on the upperside.

Body blackish, clothed with whitish hairs intermingled with black; those of the abdomen and anal tuft more greyish. Antennæ blackish, serrate internally, each joint being produced into a triangular tooth, with short whitish cilia. Haustellum fuscous, very long. Palpi clothed with long whitish hair-scales, in which a few blackish are intermingled. Eyes distinctly hairy, and with long blackish lashes. Legs black, varied with white (or *vice versâ*); tibiæ with a white fringe internally, and white at the tips; tarsi deep black, strongly (the posterior less conspicuously) annulated with white; spines of the tibiæ and tarsi short but numerous, testaceous. Anal appendages of the ♂ prominent, testaceous: the upper pair rather narrow soon after the base, but very greatly dilated at the apex, the upper edge straight, the apical edge nearly truncate, the lower edge very deeply excised; lower

pair rather broad, somewhat acuminate, curved very strongly upward, the lower edge strongly convex, the upper strongly concave: penis slender, very strongly curved.

Expanse 39 millims.

Only one ♀ from Dobbin Bay, 15th August, 1876 (*Feilden*). It is in a fair condition, but has apparently been crushed in a book.

I am unable to identify this with any described species from Lapland or boreal America, and have therefore ventured to describe it as new, notwithstanding the great variability and uncertainty in boreal Noctuæ. The most conspicuous feature consists of the pale posterior wings, with their very broad blackish border and large black central spot. A systematic examination of the anal appendages of the males of this group will certainly tend to render the separation of species comparatively easy.

I am not clear as to the true generic position. The hairy eyes would place it in *Mamestra* as defined by Grote (Bull. Buffalo Society, ii. p. 3); but the spinous tibiæ and tarsi are opposed to this connexion, as also probably are the serrate antennæ. Owing to the manner in which the example has been crushed, the dorsal crests are not definable.

A Noctua-larva indicated as from Shift-rudder Bay, August 1876 (*Feilden*), and numerous others taken from the stomach of a Tern (Discovery Bay, *Hart*), possibly belong to this species. They are of the form usual in *Mamestra*.

Plusia parilis, *Hübner*.

One worn example from Hayes Sound, lat. 79° (*Feilden*).

A rare insect, recorded from Lapland, Labrador, and Greenland. A specimen from Frau Island, Arctic America (Voyage of the 'Investigator') is in the British Museum, and forms the type of *P. quadriplaga*, Walker, Cat. Brit. Mus. Lepidopt. pt. xii. p. 911.

Geometræ.

Psychophora Sabini, *Kirby*.

Eight examples. Lat. 81° 52′, 82° 27′, and 82° 30′ (*Feilden*), in July and August, and from the 'Discovery's' winter quarters (*Hart*). Also two examples from Upernavik (*Hart*). An individual was seen by Capt. Feilden still further north, but not captured.

A known Arctic species, recorded from most of the Polar expeditions. Taken by Dr. Bessels at Polaris Bay, lat. 81° 38′.

Varies slightly, some examples having the darker central band of the anterior wings distinct, whereas in some it is scarcely indicated. The two from Upernavik are remarkable for being paler (pale silky grey), with no trace of markings. In none are the markings so sharply defined and distinct as indicated by Curtis in his figure (Appendix to Ross's Second Voyage, pl. A. fig. 12). That given by Packard (*Phalænidæ* of North America, pl. viii. fig. 20) is much better.

In Capt. Feilden's collection there is also an empty puparium, with the crippled moth that emerged from it.

Larvæ of a geometridous Moth are in Capt. Feilden's collection—one indicated as from lat. 82° 33′, and others from the stomach of a Tern, lat. 82° 27′. The full-grown larva appears very large for this insect; but still I am inclined to think these pertain thereto, especially as no other Moth of this family was observed. Dr. Bessels appears to have found the same larva at Polaris Bay.

Not being satisfied as to the true position of the insect, I have retained Kirby's generic name. Packard places it in *Glaucopteryx*, Hübner, as adopted by him. I submitted the larvæ to Mr. Buckler, so well-known for his investigations of the larvæ of British species; and he is strongly of opinion that they are related to those of the genus *Coremia*, of which he says they have the characteristic markings. The perfect insect reminds one of the genus *Cheimatobia*; but there is no real relationship.

Pyralidæ.

Scoparia gelida, n. sp.

Anterior wings very narrow and elongate, the costal margin straight, the apex subacute, with very oblique apical margin. Ground-colour smoky blackish, rather silky, sprinkled with white scales; the two transverse lines darker: first line inconspicuous, oblique, slightly angulate; second line distinct, oblique inwardly on the costal margin, then forming a very sharp curve outwardly, running inwardly almost longitudinally to within the level of the reniform spot, and then continued almost straight to the inner margin; it is bordered outwardly by white scales rather more densely placed than on the rest of the wing; the orbicular and reniform spots dark (like the lines), without pale centres; the orbicular small, placed halfway between the first line and the reniform spot; the latter larger, scarcely forming a solid 8; the claviform spot not indicated; fringes pale greyish. Posterior wings

silky pale smoky grey, rather darker at the apex, with the faintest indications of a discal dot; fringes pale silky grey. Underside uniformly very pale silky grey; the anterior pair with the usual spots and second line faintly indicated.

Antennæ black, rather silky. Palpi black, clothed with whitish scales (excepting the terminal point). Body silky blackish; the head and collar (especially beneath) clothed with whitish scales. Abdomen with a large admixture of whitish scales; anal tuft greyish. Legs blackish, considerably clothed with whitish scales; posterior tibiæ and tarsi almost entirely silky whitish.

Expanse 21–23 millims.

Three examples from lat. 82° 30′ (*Feilden*), and two from the 'Discovery's' winter quarters (*Hart*).

Probably belonging to the group of *S. sudetica*. Remarkable for its narrow and pointed anterior wings, dark colour, and the very strongly curved second line ending in the inner margin considerably within the level of the reniform spot.

TORTRICIDÆ.

There are three individuals, belonging to distinct genera and species; only two are in tolerable condition, and I do not consider it prudent to apply names to any of them.

1. *Penthina*, sp., lat. 82° 30′ (*Feilden*). A small species (expanse 16 millims.), with nearly black anterior wings with a broad darker central band.

2. *Mixodia*? sp. From the 'Discovery's' winter quarters (*Hart*). Having somewhat the aspect of *M. Schulziana*, but smaller. In the British Museum are two individuals in wretched condition from Arctic America, representing *Retinia septentrionana* of Walker's Catalogue (pt. xxxviii. p. 373); but they do not agree with the description of *Orthotænia septentrionana*, Curtis, Appendix, Ross's Second Voyage, p. 77.

3. ——. A large insect (expanse 26 millims.) from lat. 82° 30′ (*Feilden*), utterly worn and unrecognizable.

DIPTERA.

The following is Baron von Osten-Sacken's report on this Order:—

TIPULARIÆ.

Culex.—From Hayes Sound, Aug. 4th, 1875, apparently caught by a spider, which is mounted on the same slide with it. This

may be the same as *Culex caspius*, Pallas, as identified by Curtis in the Insects of Ross's Voyage (p. lxxvi). Schiödte identifies the same species with *C. nigripes*, Zett.; the latter, according to Stæger, also occurs in Greenland, and is the same as *C. pipiens*, O. Fabricius, *nec* Linné (Fn. Grœnl. p. 209). There are also larvæ and pupæ in the collection (*Hart*).

Chironomus is represented by several species, and seems to be of common occurrence. The largest species, from lat. 82° 30′, July 1876 (*Feilden*), is apparently *C. polaris*, Kirby, Suppl. to Appendix of Parry's First Voyage; also in Curtis's Insects of Ross's Voyage, p. lxxvii, pl. A. figs. 2 & 14. The same or a similar black *Chironomus* frequently occurs in temperate latitudes in winter or early spring. A small species occurred near Cape Hilgard (Aug. 14th, 1875, *Feilden*); the same or a similar species lat. 82° 33′, July 25th, 1876 (*Feilden*). From Floe-berg Beach, lat. 82° 27′, July 1876 (*Feilden*), there are two or three species, large and small; the large one appears to be different from *C. polaris*. There are also *Chironomi* from Dobbin Bay, Aug. 14th, 1875 (*Feilden*). Likewise larvæ of the genus (*Feilden & Hart*).

Sciara.—A single example of this genus from lat. 82° 30′, July 1876 (*Feilden*), a ♂ with very large forceps.

Trichocera.—Apparently the common *T. regelationis*, L. Its occurrence in Greenland is mentioned in Stæger's 'Grœnl. Antliater.' I find it from Cape Hilgard, Aug. 14th, 1875, lat. 82° 30′, July 1875; Floeberg Beach, lat. 82° 27′, July 1876, lat. 82° 30′, July 1876; and Dobbin Bay, Aug. 14th, 1875. All these are from Capt. Feilden; but larvæ were also taken by Mr. Hart. In temperate climates *Trichocera* occurs late in autumn, in winter, and in early spring; the occurrence of *T. regelationis* in July and August well characterizes the climate in which they were taken.

Tipula arctica, Curtis.—Several of this were taken by both Capt. Feilden and Mr. Hart.

Tachinidæ.—A species hatched from cocoon of *Dasychira grœnlandica*, Dumb-bell Bay, July 15th, 1876 (*Feilden*), also from another cocoon of the same Moth, Point Foulke, July 28th, 1875 (*Feilden*). Two larger Flies from Discovery Bay, Aug. 15th, 1876, seem likewise to belong to this family. Among the Insects of Ross's Voyage described by Curtis there is a *Tachina hirta*.

Muscidæ.—From lat. 82° 27′ (*Feilden*) is a Fly collected round offal, that may be *Pyrellia cadaverina*, Kirby, Faun. Bor.-Amer. p. 316 (from lat. 65°). Kirby said it was very near *P. cadave-*

rina, L. A number of specimens from Discovery Bay (carcass of a Musk-Ox, *Hart*) also belong to the same species; they agree with the specimens of *P. cadaverina*, Kirby, in the British Museum. The same or a similar fly occurred at lat. 82° 30′ and 82° 33′ (*Feilden*).

ANTHOMYIIDÆ.—From Dobbin Bay and Port Foulke, Aug. 14th and July 28th, 1876 (*Feilden*), there are *Anthomyiæ*. An *Anthomyia* is among the insects of Ross's Expedition.

MUSCIDÆ ACALYPTERA.—Specimens from Floeberg Beach, July 26th, and smaller ones from Discovery Bay, may perhaps belong to this group; but in their present state I can say nothing about them. Curtis described a *Scatophaga apicalis* from Ross's Expedition.

[The chitinous integuments of Dipterous insects were found in the stomach of *Salmonidæ* from a lake at 82° 40′ (*Feilden*).]

HEMIPTERA.

There are no true Hemiptera in the collection from north of 78°*. But the *Anoplura*, or true lice, which are generally considered as degraded forms of this order, are represented by the Walrus-parasite from Walrus Island (*Feilden*), described and badly figured by Boheman as *Hematopinus trichechi* (from Spitzbergen) in the Öfvers Vet. Akad. Förhandlingar, 1865, p. 577. This Louse is found in the axillæ and on other soft parts of the skin of the Walrus (*Trichechus rosmarus*).

MALLOPHAGA.

DOCOPHORUS CEBLEBRACHYS, *Nitzsch*.

Four examples, on its host *Nyctea scandiaca*, from lat. 82° 30′ (*Feilden*).

DOCOPHORUS, sp.?

One example on *Tetrao rupestris*, from lat. 82° 45′ (*Feilden*).

DOCOPHORUS, sp.?

One example on *Bernicla brenta*, from lat. 82° 33′, 24th June, 1876 (*Feilden*).

NIRMUS CINGULATUS (*Burmeister*), *Nitzsch*.

Three examples on *Tringa canutus*, from lat. 82° 29′, August 8th, 1876 (*Feilden*), appear to accord with the published descrip-

* From Disco Mr. Hart brought several examples of the ♀ of *Dorthesia chiton*, Zetterstedt (*Coccidæ*), already recorded from Greenland.

tion and figures. The species has been already recorded as a parasite on this and allied birds.

NIRMUS PHÆONOTUS, *Nitzsch.*

Three examples on *Phalaropus lobatus*, from lat. 82° 30′, agree well with the description and figures; but the group of species to which it belongs appear to be especially parasitic on Gulls and Terns*.

COLPOCEPHALUM, sp.?

One example on *Strepsilas interpres*, from lat. 81° 44′, 17th Aug. 1876 (*Feilden*).

MENOPON GONOPHÆUM, *Burmeister*, var.?

Many examples on *Corvus corax*, from Dobbin Bay, 29th Aug. 1876 (*Feilden*). These do not altogether agree with the figure and description in Giebel's 'Insecta Epizoa;' yet I know not to what else to refer them. Neither do they agree with Denny's figure of *Colpocephalum subæquale*, which Giebel says is not Burmeister's species of that name, and should be transferred to *Menopon*. As the Raven remains, as it were, isolated all the year in these high latitudes, it is quite reasonable to suppose that it may there possess a special parasite.

I do not regard my determinations of the *Mallophaga* as satisfactory; and it is desirable that they be hereafter reviewed by a specialist, which we now have not in this country.

COLLEMBOLA.

ISOTOMA BESSELSII, *Packard*?

Three examples from Floeberg Beach, July 1876 (*Feilden*), mounted on a slide, may perhaps belong to the above species, diagnosed by Packard (Amer. Naturalist, xi. p. 52) from Polaris Bay.

PODURA HYPERBOREA, *Boheman.*

Several examples from lat. 82° 29′, found on the surface of the snow at an elevation of 800 feet (*Feilden*), appear to agree sufficiently with the description of this species, noticed from Spitzbergen.

LIPURA, sp.?

Two individuals (mounted on a slide) from lat. 82° 30′, June 6th, 1876 (*Feilden*), appear to pertain to this genus. They are

* Three examples of a *Lipeurus* were found on *Procellaria glacialis* from Baffin Bay (*Feilden*); in all probability an undescribed species.

dark chalybeous in colour. Indicated as having been found under stones.

ARACHNIDA.

Araneidea.

The materials collected on the Expedition have been noticed and described (with other Arctic species) by the Rev. O. Pickard Cambridge, in the 'Annals and Magazine of Natural History,' 4th ser. vol. xx. pp. 273–285, pl. viii. (October 1877).

Fam. Agelenides.

Tegenaria detestabilis, *Cambridge*, sp. n., *l. c.* p. 275.

One example, Dobbin Bay, 28th Aug. 1876 (*Feilden*); found in a cabin on board the 'Alert,' and supposed by Capt. Feilden to have been introduced with plants, which were collected by nearly all the officers.

Fam. Theridiides.

Erigone psychrophila, *Thorell*; *Cambridge, l. c.* p. 278, pl. viii. fig. 4.

One example without indication of locality. Two females from lat. 82° 33′, June 21st and 24th, 1876, perhaps also belong here. Capt. Feilden (*in litt.*) says this spider was very common, and occurs as far north as he reached. Found also by the American 'Polaris' Expedition at Polaris Bay. Originally recorded from Spitzbergen.

Erigone provocans, *Cambridge*, sp. n., *l. c.* p. 279, pl. viii. fig. 5.

Adults of both sexes found in lat. 82° 27′ and 82° 33′, June 1876. Capt. Feilden says this also was common.

E. vexatrix, *Cambridge*, sp. n., *l. c.* p. 280, pl. viii. fig. 6.

One adult female from Discovery Bay (*Hart*).

In addition to these there are several examples of the genus declared by Mr. Cambridge to be indeterminable.

Fam. Lycosides.

Lycosa glacialis, *Thorell*; *Cambridge, l. c.* p. 281.

Three examples from Hayes Sound, lat. 79° (*Feilden*), and two from Discovery Bay (*Hart*). Found also at Polaris Bay.

Tarentula exasperans, *Cambridge*, sp. n., *l. c.* p. 283, pl. viii. fig. 7.

An adult male from Discovery Bay (*Hart*).

Acaridea.

Mr. Murray's illness, and subsequent death, have prevented me from giving more than a sketch of the genera &c. found during the Expedition, drawn up from disjointed notes furnished by him a few weeks before his decease. In some cases two or three forms are mounted on the same slide; so, for convenience of after reference, the numbers on the slides are here mentioned, and where species were considered by Mr. Murray to be new, the names attached by him on the slides are retained. All were collected by Captain Feilden.

Bdellidæ.

Scirus.

Several examples of a species of this genus from lat. 82° 27′, June 1876 (No. 7).

Bdella.

Possibly two species. A rather large form from lat. 82° 30′, July 1876 (Nos. 3, 4, and 6), and a smaller form from Floeberg Beach, June 1876 (*B. calandroides*, Murray, No. 5).

Hydrachnidæ.

Hydrachna.

One example from the intestines of a *Salmo* caught in a lake at Depôt Point, lat. 82° 40′, Oct. 1875 (No. 2). Another example from the same locality, taken under the same circumstances, is identified as *Eylais* ? sp. (No. 1).

Oribatidæ.

Damæus; near geniculatus, *Koch.*

From lat. 82° 30′. Several examples (Nos. 8, 9, and 10).

Oribata.

Of this genus there are probably three species. One is identified as *O. Lucasii*, Nicolet, from lat. 82° 30′, June 1876; "common under stones" (No. 10). Another, from lat. 82° 27′, June 1876, "extremely common under stones," is considered to be a new species; and the name "*triangularis*, Murray," is attached (No. 11). And there are two other slides (Nos. 6 and 10) on which are examples of the genus, from lat. 82° 27′ and 82° 30′, with no further identification.

SARCOPTIDÆ.

DERMALEICHUS.

One example of this genus of bird-mites, taken from *Stercorarius longicaudatus*, lat. 82° 27′, 8th July, 1876, bears the name "*D. stercorarinus*, Murray" (No. 12).

POSTSCRIPT. March 1878.

Mr. Butler has called my attention to the probability that *Mamestra* (?) *Feildeni* (*antè*, p. 112) is identical with *Anarta Richardsoni*, Curtis (*Hadena Richardsoni*, Curtis, in Appendix to Ross's Voyage, = *algida*, Lefebvre, = *septentrionis*, Walker), a widely-spread Arctic insect.

I was inclined to this opinion when working out the insects; but the contour of the wings appeared too different; though this is perhaps owing to the flattened condition of the type. The markings also do not fully accord with those of any specimen of *Richardsoni* seen by me; but the species is very variable. Having, however, been permitted to denude the anal parts in the type of *septentrionis* and in some examples of *Richardsoni*, I feel compelled to accept the opinion that *Feildeni* must be considered only a variety of *Richardsoni*.

The larva found by the Expedition cannot belong to this species; or, if it does, *Richardsoni* cannot be an *Anarta*.—R. M'L.

Preliminary Notice on the Surface-Fauna of the Arctic Seas, as observed in the recent Arctic Expedition. By EDWARD L. MOSS, M.D., late Surgeon H.M.S. 'Alert.' Communicated by Dr. J. MURIE, F.L.S.

[Read November 15, 1877.]

THE seas to the north of the Greenland settlements are subject to such varying conditions at different seasons of the year, that their surface-fauna cannot be supposed to be very constant. But, taking them as we found them, they may, for description's sake, be divided into three zoological regions:—

First. A district in the latitude of Melville Bay, temporarily, at least, monopolized by Peridinea.

Second. A north-water region, including the "north water" of

the whalers and all the other Polynias * between it and the perennial polar ice, and inhabited by Pteropods, Appendicularia, Chætognatha, and free Hydrozoa.

And, finally, a subglacial region tending, so far as surface-life is concerned, to be azoic.

Observations in the two former regions were of course limited to the voyages northward and southward; and, moreover, the towing-net was rarely available, for the ship when not surrounded by ice was under steam and making the most of her opportunity. But in the subglacial region observations, though limited to the neighbourhood of winter-quarters, were spread over a year, and were regularly made every fortnight except when sledging-work interfered. Water for examination was obtained through the "fire-hole," from beside the tide-float, from holes made to ascertain the thickness of the ice, and later in the season from cracks and fissures in the floes. It was taken from various depths, up to 47 fathoms, by means of "Buchanan's bottle;" and after being inspected with a strong light, was filtered in a siphon-tube through a plug of cotton small enough to be subsequently searched with a half-inch objective. A small tow-net with a weight attached near it was worked under the floes by raising and lowering it; but nevertheless, excepting occasional Copepoda, the only animal organism captured in winter-quarters was a phosphorescent Pleurobranch only 3 millimetres in diameter, caught on 30th November, 1875, in water of temperature 28°·2 Fahr.

While assisting Lieutenant Egerton in making temperature-soundings in Robeson Channel on 28th May, 1876, I observed two small *Beroës* sweep past, with the tide ebbing north, under the ice; but the water probably came from the south, as its temperature was 29° F. While running the gauntlet through Robeson Channel on our return, several *Nanomiæ* were seen, like coral necklets, in the water, and one was captured and sketched for future identification. In Discovery Habour medusiform gonophores of an undetermined Hydroid were obtained: they had six radial canals and numerous simple marginal tentacles. There, too, attached to uprooted Laminarians

* A term derived from the Russian, meaning a pool or lane of water in the ice, such as occurs in the breaking up of the ice in the Neva. Arctic voyagers apply it not only to the supposed "Open Polar Sea," but to express wide, open stretches of water in the frozen sea.—[Ed.]

we obtained a *Dendronotus*, with the right tentacle rudimentary, and an *Eolis**.

In Bessel's Bay the most northern specimens of *Oikopleura* were captured. These creatures were very common in Smith's Sound. In Payer Harbour, lat. 78° 44′ N., on 3rd August, 1875, as many as a dozen at a time could be counted floating past in the intensely green water, each enveloped in its "Haus." They were unusually large, measuring as much as 2·5 centims. in length, and the "Haus" about 5 centims. in diameter. The brilliant scarlet contents of their stomachs made them very conspicuous objects. The scarlet matter consisted of various-sized homogeneous globules, identical in appearance with the yelk-substance of certain nidimental ribbons common in the surface-water of Smith's Sound. One specimen of *Fritillaria* was obtained off Cape Isabella. Both these genera of Appendicularia are new to Arctic seas, though *Oikopleura* was originally discovered in Behring Straits.

The north water of Smith's Sound also abounds in *Clio borealis*, preying on *Limacina* and its fry. The *Clio* fry were belted with one interrupted and two continuous circlets of cilia.

Sagittæ were also common both there and in Baffin's Sea. They differed so slightly from the universal "*bipunctata*" of Quoy and Gaimard, that I include them in that species. They were, however, spineless except for the setæ on the lateral fins. In southern *Sagittæ* the spines, as Mr. Busk observes, are very easily detached, and are often absent in preserved specimens; but amongst the several large specimens captured uninjured in Melville Bay, I failed to find either spines or the bulbs from which they usually spring. Two varieties were captured, differing only in the shape of the caudal fin: in the one it was continuous, in the other interrupted at the tip. The fins are sometimes different on either side of the same animal.

It is worthy of remark that the rays of the fins occur in double series closely applied to each other; one set is sometimes seen inclined or bent in a direction not parallel to those above or below. I have since seen this double character in *Sagittæ* from the South Pacific. The cephalic hooklets were twelve in number. The anterior denticles of Krohn were four to six, and the posterior eighteen to twenty. The corneal cells surrounding the ophthalmic pigment-points formed

* Since determined as *Eolis salmonacea*, Couthouy, by Mr. Edgar A. Smith ('Annals and Magazine Nat. Hist.' 1877, xx. p. 140).

a continuous circle, and were not broken into three groups as in the *Sagittæ* described by Huxley.

The Peridinea of Melville Bay were of at least three species; without reference I can identify but one of them, namely *Ceratium tripos*. The others were comparatively rare; but this Infusorian was present in such extraordinary abundance that the cotton filters were generally choked in a few minutes. The most northern specimens were met with at our turning-point in Buchanan Strait.

The most northern living Radiolarian was an *Acanthometrina* captured in Davis Straits; but empty skeletons of *Dictyocha* were occasionally caught by the cotton filter in Baffin's Sea; and Radiolarian fragments were not uncommon in the "floeberg dust" of the far north. A Gregarina, apparently *Pyxinia*, was found entangled in a mass of awned Diatomaceæ in Allman Bay.

In connexion with the absence of surface-life under the ice, I may observe that a *Sagitta* and two Copepods exposed in a cell under the microscope and allowed to freeze were killed in a few minutes; death occurred before the more salt parts of the water crystallized. No living animal organism of any kind was found in the polar ice; but Diatomaceæ with endochrome still retaining its colour were once or twice met with in the floebergs, and were not uncommon in the large white flocculi set free to sink when the ship "rammed" her way amongst the more southern floes.

Postscript. April 1878.

The specimens of Copepoda referred to have since been named by the Rev. A. M. Norman, and the Discovery-Harbour Medusa has been placed in a new genus by Professor Allman. For both see Sir George Nares's Appendix*.

The polar *Pleurobranchia* was a young specimen of *P. rhododactyla*, Agassiz.

The *Nanomia* was probably *N. cara*, A. Agassiz. Identification, however, depends only on the sketch; for the specimen bottled by Captain Feilden has fallen to pieces.

The Appendicularia are:—

Oikopleura rufescens, Fol.
Fritillaria furcata, var., Fol.

The Melville-Bay Peridinea include:—

Ceratium tripos, var. γ (slender and unserrated), Claparède and Lachmann.

* Narrative of a Voyage to the Polar Sea, 1875–76.

Ceratium divergens, Claparède and Lachmann.
Peridineum Michælais, Ehrenberg.
P. acuminatum, Ehrenberg.
Dinophysis norwegiana, Claparède and Lachmann.

There are also "resting-spores" of Peridinea in reticulated cases and some empty shells of *Tintinnus*.—E. L. M.

On the Annelids of the British North-Polar Expedition. By W. C. M'Intosh, M.D., LL.D., F.R.S., F.L.S.

[Read November 15, 1877.]

Captain Feilden, one of the naturalists of the late Arctic Expedition under Sir George Nares, kindly placed in my hands a small collection of Annelids dredged between latitudes 79° and 82° 30′ N. In glancing over the twenty forms in this collection it is found that eight species (or forty per cent.) are not mentioned in the paper (recently communicated to the Society) on the Annelids procured by Dr. Gwyn Jeffreys, F.R.S., when dredging in H.M.S. 'Valorous' in Davis Strait. Two of these, however, are known to inhabit the Gulf of St. Lawrence, where they were lately dredged by Mr. Whiteaves. No species new to science is present; and, with one exception, all have been previously entered in the catalogue of the Greenlandic fauna*.

The majority of the species represented in the collection have a very wide range in northern waters, many being common to the British seas and the shores of the North Atlantic generally, and on the American side stretching from the Gulf of St. Lawrence north-eastward to the polar ice beyond Smith's Sound. With two exceptions all the species occur in the seas of Spitzbergen, and one of these is Icelandic, while the second is a somewhat doubtful form. This distribution is therefore clearly marked; but it is well to bear in mind that the Annelids of the North-American shores have been only partially investigated, and that a critical revision, by one familiar with North-European forms, of what has been accomplished in this respect is yet a desideratum. On the whole, the circumpolar Annelidan fauna would appear to present considerable uniformity in regard to species.

* Arctic Manual, 1875.

The appearance and size of the specimens afford good grounds for believing that many species, genera, and families yet remain to be discovered in these high polar latitudes. The large size of the Polynoidæ and the abundance of *Loxosomæ** on their scales and other parts are features of interest. The occurrence also of a considerable quantity of the tubes and bodies of a species of *Sabella* in the stomach of the Great Seal (*Phoca barbata*, Fabr.) adds another instance to the list of cases in which Annelids are eaten by the higher animals. The stomach of the same Seal further contained, besides the spawn of fishes, two examples of *Priapulus caudatus*, Lam., and several curiously coiled cords of ova, which resembled Annelids.

In Dr. Emil Marenzeller's account† (just published) of the Annelids procured by the Austro-Hungarian North-Polar Expedition, under Lieutenants Weyprecht and Payer, 27 species are mentioned. Of these, no less than 18 do not occur in the following list; but no further weight should be put on this than is warranted by the fact that only a few of the abundant forms which have a wide circumpolar range had been obtained in either case. Many of the 18, indeed, occur on the Canadian coast, and extend northwards to Davis Strait. On the other hand, about half the species (11) in the English Expedition do not appear in the Austro-Hungarian. Three of the species in the latter list do not occur in the catalogue in the 'Arctic Manual' (1875), and a fourth forms a new genus. They were procured between 74° and 79° N. lat. The species common to both Expeditions are indicated in the table at the end; those characteristic of the Austro-Hungarian Expedition are :—*Eucrante villosa*, Mgrn.; *Nephthys longisetosa*, Œrst.; ? *Phyllodoce Luetkeni*, Mgrn.; *Syllis fasciata*, Mgrn.; *Nereis pelagica*, L.; *Nothria conchylega*, Sars; *Glycera capitata*, Œrst.; *Scalibregma inflatum*, H. Rathke; *Brada villosa*, ibid.; *Ampharete Goësi*, Mgrn.; *Amphicteis Gunneri*, Sars; *Melinna cristata*, Sars; *Amphitrite cirrata*, O. F. Müller; *Terebellides Stroemi*, Sars; *Euchone tuberculosa*, Kröyer; *Chone Duneri*, Mgrn.; *Spirorbis lucidus*, Mont.; and *Hyalopomatus Claparedii*, Marenzeller.

* Prof. Busk and the Rev. T. Hincks are at present engaged with these curious forms.

† "Die Cœlenteraten, Echinodermen und Würmer der k.-k. österreichisch-ungarischen Nordpol-Expedition," &c., Bd. xxxv. der Denkschriften der math.-naturwiss. Classe der k. Akad. der Wissenschaften, 1877.

Fig. 1.

Sketch Map showing route of the late Arctic Expedition.

Fam. POLYNOIDÆ.

NYCHIA CIRROSA, *Pallas**.

Fragment of a large example from Cape Frazer, Grinnell Land, 79° 44′ N. lat., in 20 fathoms, on stony ground. Two specimens from Station No. 29 have the dorsal bristles covered with an ochreous investment, amongst which are many Infusoria.

This species is common in Britain, Scandinavia, Iceland, Spitzbergen, and Greenland.

EUNOA ŒRSTEDI, *Malmgren*.

A fine specimen from Franklin-Pierce Bay, Grinnell Land, at a depth of 15 fathoms, in 79° 25′ N. lat. Bottom-temperature 29°·50. *Tubulipora* and *Halisarca* occur on the scales.

The length of the example is about 78 millims., and breadth 25 millims. The species is not uncommon in the Gulf of St. Lawrence, and ranges northward to Greenland, to Spitzbergen, Iceland, and Finmark.

EUNOA NODOSA, *Sars*.

A large example from Cape Louis Napoleon, Grinnell Land, lat. 79° 38′ N., in 25 fathoms; bottom-temperature 29°·2. A small *Tubulipora* and many Foraminifera are attached to the scales.

E. nodosa ranges from Britain to Finmark and Spitzbergen, and from the Gulf of St. Lawrence to Greenland.

LAGISCA RARISPINA, *Sars*.

An adult form (with smoother scales), measuring 55 millims. in length and 17 in total breadth, from Cape Napoleon, 25 fathoms; and a small variety, with more numerous cilia on the scales, from Franklin-Pierce Bay, in 15 fathoms. Numerous *Loxosomæ* are attached to the scales of the former. The eyes in the smaller form are larger and the tips of the bristles slightly differ.

Widely distributed in northern waters from Norway to Iceland and Spitzbergen, and from the Gulf of St. Lawrence to Greenland.

HARMOTHOË IMBRICATA, *L*.

A large specimen from Floeberg Beach (the winter-quarters of H.M.S. 'Alert'), 82° 27′ N. lat.; smaller forms from Bessels Bay, 81° 7′ N. lat., in 7½ fathoms, and from Station No. 29.

* The arrangement and synonymy of Dr. Malmgren (Annulata Polychæta, &c., 1867) is followed. Special reference to authorities is therefore unnecessary.

One example had the same whitish tubercles (containing granules) in its skin as observed in *Nychia cirrosa* of the 'Valorous'*.

Abundant in all northern waters.

Antinoë Sarsi, *Kinberg*, ? var. grœnlandica, *Mgrn.*

A large example, 50 millims. in length and about 20 in total breadth, from Discovery Bay (the winter-quarters of H.M.S. 'Discovery'), in 81° 44′ N. lat.

Fig. 2.

Head of *Antinoë Sarsi*, slightly magnified.

The head of this specimen (fig. 2) differs from the ordinary form in having the posterior pair of eyes in a line passing transversely across the middle of the head, and therefore advanced to an unusual degree. The anterior pair are placed laterally, a little behind the anterior prominence. The dorsal bristles are very long, much longer than in Malmgren's figure, indeed they project outward as far as the ventral.

A *Loxosoma* occurred on the feet; and on the same parts a parasitic Infusorial form covered the cuticle and the bristles with a minute down, rising here and there on the former into little elevated tufts, and evidently flourishing in great profusion.

A. Sarsi in its ordinary form occurs in the Baltic, at Spitzbergen, Finmark, and from the Gulf of St. Lawrence northwards to Greenland.

Fam. Phyllodocidæ.

Phyllodoce grœnlandica, *Œrsted.*

Two specimens of average size were collected in Franklin-Pierce

* Proceed. R. S. vol. xxv. No. 173, p. 216.

Bay by Mr. H. C. Hart; others come from Cape Frazer in 30 fathoms (mud), Discovery Bay in 5 fathoms, and in 35 fathoms at Hayes Point.

Ranges from Britain to Finmark, Spitzbergen, Gulf of St. Lawrence, Greenland, and probably in most northern seas.

AUTOLYTUS LONGISETOSUS, *Œrst.*

On a muddy bottom in 11 fathoms in 81° 44′ N. lat.

All are sexual forms (males), and the beautiful iridescence of their long bristles is striking. O. Fabricius* named the same form *Nereis prismatica*; and he found them for the most part in masses of a yellow fœtid sponge.

The species ranges from Greenland to Spitzbergen.

Fam. NEREIDÆ.

NEREIS ZONATA, *Malmgren.*

Dredged in 15 fathoms, Franklin-Pierce Bay; bottom-temperature 29°·50.

Not uncommon at Spitzbergen and Greenland.

Fam. LUMBRINEREIDÆ.

LUMBRICONEREIS FRAGILIS, *O. F. Müller.*

A specimen of considerable size (about 9 millims. in diameter) from Discovery Bay, in 5 fathoms.

Abundant in all northern waters.

Fam. SCALIBREGMIDÆ.

EUMENIA CRASSA, *Œrsted.*

A full-grown example from Cape Frazer, on stony ground, in 20 fathoms.

Ranges from Britain to Scandinavia, to Spitzbergen and Greenland.

Fam. HALELMINTHIDÆ.

CAPITELLA CAPITATA, *Fabr.*

A fragment from Discovery Bay.

Generally distributed in the northern seas.

Fam. AMPHICTENIDÆ.

CISTENIDES GRANULATA, *L.*

From Discovery Bay.

* 'Fauna Grœnlandica,' p. 302.

The tubes are for the most part composed of the same quartzose sand as in the examples from the 'Valorous.' The specimens are rather small, the longest tube being 41 millims. in length, and 7 millims. in diameter at the anterior end.

Not uncommon at Iceland and Greenland.

Fam. AMPHARETIDÆ.

AMPHICTEIS SUNDEVALLI, *Malmgren.*

A very fine example (measuring 42 millims. in length and 11 in breadth) from Discovery Bay, in 5 fathoms.

This agrees with Malmgren's description in having 19 segments with pinnules in the posterior region of the body. The bristles are rather more crenated, and their shafts more distinctly striated than in *Amphicteis Gunneri*, Sars; but the most characteristic difference appears in the hooks, which certainly diverge in a noteworthy degree.

This species has hitherto been procured only on the eastern shores of Spitzbergen, on a clayey bottom.

Fam. TEREBELLIDÆ.

SCIONE LOBATA, *Malmgren.*

From Franklin-Pierce Bay, collected by Mr. W. C. Hart. In tubes composed of coarse chitinous secretion, with adherent sand-particles, Foraminifera, and other minute organisms.

Not rare at Spitzbergen and Greenland.

Fig. 3.

Axionice flexuosa, Grube, in tube, enlarged.

AXIONICE FLEXUOSA, *Grube.* (Fig. 3.)

From Floeberg Beach in 10½ fathoms. A single specimen in a somewhat friable flattened tube, composed of chitinous secretion and quartzose sand. The regular curves of the tubes are remarkable.

Common on the shores of Spitzbergen and Greenland.

THELEPUS CIRCINNATUS, *Fabr.*

A fragment from Cape Frazer in 20 fathoms, on stony ground.

Everywhere common in the northern seas.

Fam. SABELLIDÆ.

? SABELLA SPETSBERGENSIS, *Malmgren.*

From Franklin-Pierce Bay, in 13–15 fathoms, on a stony bottom (Mr. W. C. Hart). The absence of the branchiæ renders accurate diagnosis difficult.

This form also occurs in considerable quantity from the stomach of *Phoca barbata*, Fabr.

EUCHONE ANALIS, *Kröyer.*

From Discovery Bay, lat. 81° 41′ N.

In tubes of particles of quartz, fragments of shells, and spines of *Echini*, with sand-grains and secretion.

Not uncommon on the shores of the North Atlantic—from Britain to Scandinavia, Spitzbergen, and Greenland.

CHONE INFUNDIBULIFORMIS, *Kröyer.*

From Discovery Bay. The specimen is of medium size and in the ordinary chitinous tube.

Occurs in Britain, Finmark, Spitzbergen, and on the American side from the Gulf of St. Lawrence to Greenland.

Fam. LUMBRICIDÆ.

CLITELLIO ARENARIUS, *O. F. Müller**.

Specimens were found clinging to roots of *Laminariæ* in 82° 30′ N. lat.

This species does not appear to have been rediscovered since O. Fabricius described it.

NEMERTINEA ANOPLA.

Fam. LINEIDÆ.

Two examples, apparently the *Planaria fusca* of Fabricius †, come from Franklin-Pierce Bay, in 15 fathoms. Bottom-temperature 29°·50. The appearance of the specimens and the structure of the proboscis (which is very well shown) make it probable that the species indicated by Fabricius is very closely related to *Micrura fusca*, McI.‡ The styliform process at the tail may have been overlooked.

* O. Fabricius, 'Fauna Grœnlandica,' p. 280.

† 'Fauna Grœnlandica,' p. 324.

‡ Brit. Nemerteans, Ray Soc, p. 196.

	N. lat.	Bottom-temperature.	Depth in fathoms.	Bottom.	Austro-Hungarian Exped.	European.	North-American.
Nychia cirrosa, *Pall.*	79° 44′	...	20	stones.	*	*	*
	81° 44′	29°·0					
Eunoa Œrstedi, *Mgrn.*	79° 25′	29°·50	15	...	...	*	*
Eunoa nodosa, *Sars*	79° 38′	29°·2	25	...	...	*	
Lagisca rarispina, *Sars*	79° 38′	...	25				
	79° 29′	...	15	...	...	*	*
	79° 25′	29°·50	15				
Harmothoë imbricata, *L.*	82° 27′						
	81° 7′	...	7½	...	...	*	
	81° 44′						
Antinoë Sarsi, *Kbg.*	81° 44′	...	...	...	*	*	*
Phyllodoce grœnlandica, *Œrst.*	79° 29′	...	...	...	*		
	79° 44′	...	30	mud.	...	*	*
	79° 40′	...	35				
	81° 44′	...	5				
Autolytus longisetosus	81° 44′	...	...	...	...	*	
Nereis zonata, *Mgrn.*	79° 29′	29°·50	15	...	*	*	*
Lumbiconereis fragilis, *O. F. Müller*	81° 44′	...	5	...	...	*	
Eumenia crassa, *Œrst.*	79° 44′	...	20	stones.			
Capitella capitata, *Fabr.*	81° 44′	29°·0	...	...	...	*	*
Cistenides granulata, *L.*	81° 44′	30°·0	...	...	*		
Amphicteis Sundevalli, *Mgrn.*	81° 44′	...	5				
Scione lobata, *Mgrn.*	79° 29′	...	...	...	*		
Axionice flexuosa, *Grube*	82° 27′	...	10½				
Thelepus circinnatus, *Fabr.*	79° 44′	...	20	stones.	*	*	*
Sabella spetsbergensis, *Mgrn.*	79° 29′						
Euchone analis, *Kröyer*	81° 41′	29°·0	...	...	..	*	
Chone infundibuliformis, *Kröyer*	81° 44′	...	...	...	*	*	*
Lineus fusca, *Fabr.*	79° 25′	29°·50	15				
Clitellio arenarius	82° 30′	...	...	...	...	*	

Report on a Small Collection of Insects obtained by Dr. J. C. Ploem in Java, with a Description of a new Species of *Hoplia*. By CHARLES O. WATERHOUSE, Esq. Communicated by Dr. J. MURIE, F.L.S.

[Read December 6, 1877.]

[IN March last (1877) Dr. J. C. Ploem, Director in Chief of the Hospital at Sindang-læeja, in the island of Java, kindly forwarded to our Society a small collection of insects made by him in the

neighbourhood of the above-mentioned locality. Unfortunately they arrived too late to be exhibited at the last Meeting in June. Being placed in Mr. Waterhouse's hands for identification during the recess, the accompanying Report is the result of his examination. It may be mentioned that Dr. Ploem transmitted the insects by post enclosed within a thickish joint of Bamboo, and, saving the smaller delicate specimens, they arrived in tolerably fair condition.—J. M.]

I have examined the contents of the bamboo tube sent by Dr. Ploem to the Linnean Society, and with the following result:—

Coleoptera.

1. Several specimens of a species of *Hoplia* new to science, of which I append a description.
2. Two specimens of *Popilia biguttata*, Wiedemann.
3. One male example of *Chalcosoma atlas*, Linn.
4. One example of *Dascyllus fulvulus*, Wiedemann.

With regard to this species, it is worthy of notice that the specimen sent differs from the one in the British-Museum collection in being a little larger ($5\frac{1}{2}$ lines long), in having the thorax broadest *at* the posterior angles instead of a little *before* the angles; and the striæ of the elytra are only lightly impressed and the interstices nearly flat, whereas in the Museum example the striæ are very deep and the interstices very convex.

They may prove to be two distinct species; but having only these two specimens, I should not like to describe the one sent as new.

5. The only other Coleopterous insect is a species of *Rhyparida* (Eumolpidæ); but for this I have not been able to find a specific name at present.

The other insects are two species of *Gryllus*, and one very curious species of *Forficula*, remarkable for having on the upper side of the base of the forceps a pair of well-developed club-shaped tubercles. I have not had time to determine these species.

There are the remains of two other insects; but they are not recognizable.

Melolonthidæ.

Hoplia aurantiaca, sp. n.

Oblonga, parum convexa, rufo-picea, squamis aurantiacis et ochraceis fulgidis dense vestita. Long. 3 lin., lat. $1\frac{1}{2}$ lin.

A pitchy red species, densely clothed (even on the legs and tarsi) with bright golden and ochraceous round scales; the ochraceous scales form on the thorax a patch above each anterior angle and a line on each side of the middle; on the elytra a small spot on the side (about the middle), and a larger oblique subapical patch not reaching the suture; these ochraceous scales also appear golden when viewed obliquely. The scales on the abdomen and pygidium are more silvery. The clypeus has the margins distinctly reflexed and the angles much rounded. Thorax a little narrower than the elytra, one fourth broader than long, distinctly narrowed in front and behind, angular at the sides, regularly convex above. Elytra one fourth longer than broad, moderately depressed above, but not flat; the sides are subparallel, scarcely arcuate, the subapical callosity very little prominent. In some lights the golden scales on the elytra present a mark like an X, embracing the more ochraceous scales.

Notes touching Recent Researches on the Radiolaria. By St. George Mivart, Zool. Sec. Linn. Soc.

[Read January 17, 1877.]

The example which has been set by our President in publishing * from time to time in his successive Addresses a digest and *résumé* of the most recent researches which have been carried on respecting certain of the lowest animal groups, has led me to believe that a similar course might advantageously be taken with respect to the Radiolaria. Our publications already afford, through Dr. Allman's recent labours, the readiest means of obtaining a knowledge of the most modern investigations with respect to various groups of Protozoa; and I have myself found the memoirs referred to most valuable and useful. I hope that other Fellows may adopt a similar course; so that our Journal may become a complete repertory of information respecting all the lower groups of the animal kingdom. No English publication on the Radiolaria exists to my knowledge; and although the most admirable monograph † of Professor Haeckel

* 'Proceedings' for May 24th, 1875; Journal, vol. xiii. No. 69, p. 261, and No. 71, p. 385.

† 'Die Radiolarien,' 1862.

was, at the time, a complete and exhaustive account, yet, were it even readily and generally accessible, important additions have now been made to our knowledge of these animals since its publication. I venture to think therefore, and my opinion has been confirmed by very high authority (that of our esteemed President), that an account of these beautiful, and in many respects complex, organisms will not be an unwelcome addition to English zoological literature.

Under the name *Radiolaria* are comprised a great number of minute, very varied, and beautiful organisms which are found swimming near the surface of the water, and which considerably resemble the Heliozoa, but are of more complex structure.

Each individual consists of two portions of coloured or colourless *sarcode*—one portion nucleated and central, the other portion peripheral and almost always containing certain *yellow cells*. These two portions are separated by a porous membrane called the *capsule**; and the whole is invested by a generally very delicate gelatinous layer. The sarcode, moreover, sends forth, mostly on all sides, multitudinous radiating, filamentary prolongations of its substance, the *pseudopodia*, which may or may not branch or anastomose.

In most species skeletal structures are developed in the sarcode either outside or inside the capsule, or both without and within it, and generally in the form of spheroidal investing networks, or of radiating spines, or of combinations of these, though sometimes reduced to a few filamentary or branched spicula. Whatever its form, the skeleton is almost always siliceous, and is never calcareous †.

The individuals (or zooids) of some species, both of kinds provided with and others destitute of skeletal structures, naturally

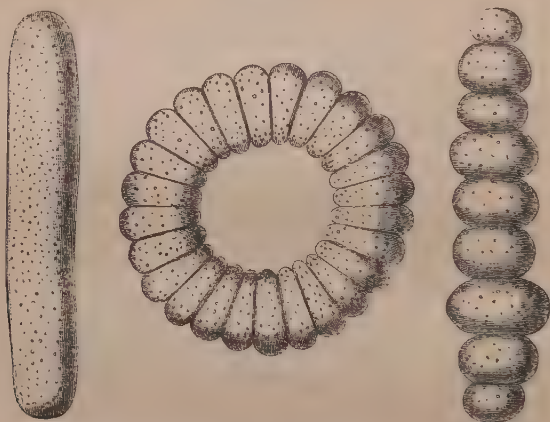
* Sir C. Wyville Thomson speaks of Radiolarians destitute of a central capsule ('Voyage of the Challenger,' vol. i.). If this is not a clerical error, some very interesting new forms may be expected to be made known by the publication of the 'Challenger's' zoology. But whatever novelties may be forthcoming, forms without a central capsule should, I think, be excluded from the Radiolaria.

† The calcareous bodies found in the extracapsular sarcode of *Myxobrachia* I do not regard as forming a real exception. As to the calcareous forms noticed and figured by Sir C. Wyville Thomson ('Voyage of the Challenger,' vol. i. p. 233) under the name of *Calcaromma calcarea*, we must wait for more detailed and exact information. I cannot but think it possible that its calcareous particles may really be extraneous bodies, as also those of *Myxobrachia*.

cohere in compound masses or colonies which may assume various shapes—cylindrical, spheroidal, or like a chain, or even a circlet of beads. There may be many more than a thousand zooids in such aggregations, which may attain a length of 50 millims.

In colonies, the gelatinous investment attains a greater size than in most of the solitary forms.

Fig. 1.



Different forms assumed by colonies of *Collozoum inerme*.
(After Haeckel.)

The name "Radiolaria" was first used by the great John Müller, who in 1858 united together, under this designation, the three groups known as *Polycystina*, *Thalassicolla*, and *Acanthometra*.

The first Radiolaria noticed were more or less indistinctly referred to in investigations as to the causes of marine luminosity by Tilesius *, Baird †, and Ehrenberg ‡.

Two definite species, one simple and one compound (*Physematium* and *Sphærozoum*), were distinctly indicated by F. Meyen § as early as 1834.

A great number of fossil kinds were subsequently made known

* Naturalist to Krüsentern's Circumnavigation in 1803–1806. See Tilesius's 'Ueber das nächtliche Leuchten des Meerwassers,' p. 367, tab. xx *a*.

† Loudon's 'Magazine of Natural History,' vol. iii. 1830, p. 312, fig. 23 *a*.

‡ "Das Leuchten des Meeres," Abhandl. der k. Akad. Berlin, 1834, p. 411.

§ Nov. Act. Acad. Leop.-Carol. vol. xvi. Suppl. 1834, pp. 159–164, t. xxviii.

by Ehrenberg, which he assembled together under the name *Polycystina*, and to these living forms were subsequently aggregated.

Professor Huxley, while on board H.M.S. 'Rattlesnake,' discovered certain marine organisms, to which he gave the generic name *Thalassicolla*; and his description in 1851* first made known the main points in Radiolarian anatomy.

In 1855 John Müller described † certain star-like organisms to which he gave the name *Acanthometra*, and subsequently (as before said) united them with other groups as Radiolaria in a memoir ‡ which is the first great work on the anatomy of both the hard and soft parts of these organisms.

In 1862 Professor Haeckel published his magnificent and classical work 'Die Radiolarien,' containing not only the most complete account of the structure of the whole group, but copious references to all preceding writers, as well as a description of a multitude of new genera and species, with an Atlas of thirty-five beautiful folio plates drawn by himself.

Had this illustrious naturalist done no other scientific work, this alone would suffice to procure him enduring fame.

Since this epoch-making work there have appeared other papers by the same author describing new genera and species, and also papers by Dana, Schneider, Wallich, Stuart, Wagner, Focke, Greef, Archer, Macdonald, Donitz, Cienkowski, Hertwig and Lesser, and Hertwig, which will be enumerated in the list of the literature of the Radiolaria at the end of this memoir, and will be incidentally referred to as occasion requires. It will suffice here to make special mention of Cienkowski's researches § on the reproduction of Radiolarians, and of Dr. Richard Hertwig's admirable paper || on the same subject and on the anatomy of certain forms.

The individual Radiolarians or zooids vary in size from about $\frac{1}{600}''$ to about $\frac{1}{20}''$; but they are for the most part invisible to the naked eye, though rarely, as in *Myxobrachia* (an elongated form), they may attain the length of 14 millims.

Mostly spheroidal, they may yet be conical, cylindrical, lens-

* Ann. & Mag. Nat. Hist. ser. 2, vol. viii. p. 433.

† Monatsberichte Berlin, 1855, p. 671.

‡ Abhandl. d. könig${}$. Akad. Berlin, 1858, pp. 1–62, pls. i.–ix.

§ Archiv für mikrosk. Anat. vol. vii. p. 371 (1871).

|| 'Zur Histologie der Radiolarien,' 1876.

shaped, or in the form of flattened disks, and such disks may be here and there enlarged by having wide arm-like productions.

The *sarcode* is a homogeneous protoplasmic substance containing granules. A chitinous membrane divides it, as before said, into an intra- and an extracapsular scarcode, these parts being directly continuous through minute pores which perforate the membranous capsule. The sarcode may be extremely fluid, as in *Collosphæra*, or relatively firm, as in *Acanthometra*.

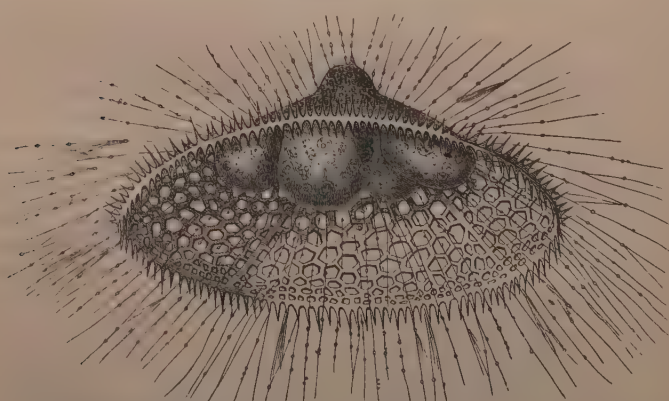
In most solitary forms the capsule is very large relatively to the whole mass, the extracapsular sarcode being relatively scanty. In some forms, however, the reverse is so much the case that the diameter of the capsule may be but about one fifth of the whole organism, as is the case in *Thalassicolla*. In the compound forms (colonies) the capsules appear as small spheres scattered through the relatively large mass of extracapsular sarcode and gelatinous investment.

The size of the capsule may vary from about 2 millims. (*Thalassolampe* and *Physematium*) to 0·025 millim. (*Zygostephanus*).

It is formed of a relatively strong membrane perforated by very numerous minute apertures or pores, and sometimes marked by lines dividing its surface into irregular polygonal segments, as in *Thalassicolla*.

Its shape is mostly spheroidal; but this may vary with the shape of the entire organism. It may also be vertically elongated, with terminal or median enlargements, or both; or (as in some

Fig. 2.



Eucecryphalus Schultzei, showing the lobed central pseudopodia and capsule and the oil-globules within them. (After Kölliker.)

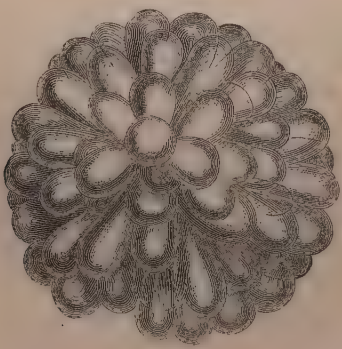
Cyrtida) it may have the form of a cone, with its base provided with three or four rounded processes.

In no part of the sarcode do we find habitually contractile spaces (as we do in the Heliozoa); but we may find in the intra- or extracapsular sarcode, or in both, rounded spaces, called *alveoli*, which are mere vacant spaces save for fluid contents, and are devoid of any limiting membrane. They are often considerable both in size and number. The sarcode surrounding some of these alveoli may be so contractile as to occasionally obliterate them, and so, by increasing the specific gravity of the organism, enable it to sink. It is only the more superficially placed alveoli, however, which have been observed so to disappear.

The intracapsular sarcode contains alveoli in *Thalassicolla*, *Thalassolampe*, and *Physematium* only; but, besides certain other formations more or less frequently present, it constantly contains one or both of two sets of structures, which structures, according to the researches of Hertwig, bear to the whole capsule the relation of many simple nuclei or of a single complex nucleus to a cell.

The simple nuclei (the "*wasserhellen Bläschen*" of authors) are rounded homogeneous particles of denser sarcode devoid of investing membrane, and varying in size from about 0·008 millim. to about 0·015 millim., the largest in size being found where the substance is least. They may be so numerous as to fill the capsule, and acquire by reciprocal pressure a polyhedral aspect; or they may be very few and grouped together towards the centre of the capsule; or, finally, when a complex nucleus is present, they may be altogether absent.

Fig. 3.



Nuclear vesicle of *Myxobrachia pluteus*. (After Haeckel.)

The complex nucleus is a small vesicle (the "*Binnenbläschen*" or "*vesicula intima*" of authors) formed of porous membrane similar to, but still more delicate than, the capsule itself. It may be simply spheroidal, or it may be produced on all sides into a number of rounded processes, as in *Thalassicolla*, and still more in *Myxobrachia* (fig. 3). Its contents are mainly clear and homogeneous; but Hertwig has shown that minute bodies become developed within it, which he considers to be nucleoli, and which are said to pass outwards through the membrane and to grow into and become the simple nuclei before described. *Pari passu* with this extrusion of nucleoli and consequent multiplication of nuclei, the *vesicula intima* shrivels. This complex nucleus has as yet only been found in the genera *Thalassicolla*, *Thalassolampe*, *Myxobrachia*, *Physematium*, *Aulacantha*, *Aulosphæra*, *Heliosphæra*, and doubtfully in *Diplosphæra*.

Besides the nuclei, *fatty bodies* (formed of albuminoid substance and adipose matter) are also present in most cases, but are generally absent in young individuals. These fatty bodies have mostly the form of a relatively larger central body with smaller ones scattered round it; and when the capsule is elongated in shape, it has generally one such body near each end.

The intracapsular sarcode may appear colourless and transparent, as in *Heliosphæra*, in many kinds of *Acanthometra*, and others, or it may seem strongly coloured. The commonest colours are yellow, red, or brown; but purple, violet, blue, or olive-green are found in a few species. Two colours rarely coexist in one capsule. In *Spongocyclia* and *Spongastericus* the inner part of the capsule is scarlet and the outer part golden yellow. The sarcode is not itself coloured, nor does it contain coloured fluids. The pigment exists in granules or small vesicles.

In a very few genera (*Thalassicolla*, *Thalassosphæra*, *Acanthochiasina*, and at least one *Acanthometra*) we find scattered in the sarcode small bodies called "*concretions*," in the form of round or elliptical disks, the sides of which may be flat or more or less strongly convex *. In *Thalassicolla* these concretions, and also fatty bodies, appear environed by, or connected with, certain peculiar bodies of doubtful nature, to which the name "*Eiweisskugeln*" has been given †. The concretions consist of leucin ‡ and tyrosin §, and

* See Haeckel's 'Radiolarien,' pl. iii. fig. 3.

† Hertwig, 'Histologie,' table iii. fig. 9.

‡ $C_6H_{11}(NH_2)O_2$. § $C_2H_{11}NO_3$.

are soluble both in acids and alkalies. It may be that they are undigested remnants of food.

Other bodies *, of a crystalline structure, are found in a very few forms, such as *Collozoum*, *Sphærozoum*, *Thalassicolla*, and *Collosphæra*. Those in the last-named genus are about $\frac{1}{60}'''$ long. These crystals are said to be insoluble not only in cold and hot water, but even in cold or hot acids and alkalies.

In a single Radiolarian (*Physematium Mülleri*) Haeckel found scattered round the inside of its capsule groups of three to five pear-shaped cells 0·05–0·06 millim. in length, with their apices mediad †, each enclosed in a membrane and with a granular nucleus. The broad end of each group lies against the inner surface of the capsule. Haeckel suspects that it may be perforated, and so serve as a channel of communication between the intra- and extracapsular sarcode. He calls these groups of cells "*centripetal Zellgruppen*."

As before said, the extracapsular sarcode invests the capsule more or less thickly on all sides, and is itself invested externally by a more or less perceptible gelatinous layer; but no membrane exists beneath or outside that layer.

Alveoli are present in this part of the sarcode of a few simple Radiolaria (*Thalassicolla*, *Aulacantha*) and in all the compound forms, where their great number and size seem the main conditions of the volume of each colony. One excessively large nucleus may occupy the centre of the colony, as in *Collosphæra*, showing one large central alveolus, with circumferential fully-developed capsules and other more central capsules in process of development, also many yellow cells amongst the radiating pseudopodia and the circumferential capsules. The alveoli may, on the contrary, be much larger superficially and smaller within, as in *Thalassicolla*; they are, of course, bounded on all sides by the sarcode, and in the complex forms are bordered by those of the pseudopodia, which radiate inwardly from the several zooids.

The extracapsular sarcode also sometimes contains pigment which is generally black, or black-brown, or red-brown, or dark violet. It is aggregated in granules or vesicles, and is generally collected towards the deepest layer next the capsule.

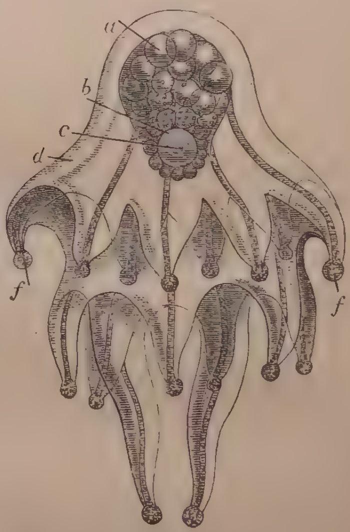
Nothing at all resembling concretions is found in the external

* See Müller, Abhandl. Berlin, 1858, pl. viii. fig. 9; and Haeckel, *l. c.* pl. iii. fig. 3.

† 'Radiolarien,' pl. iii. fig. 7; and Kolliker's 'Icones Histologicæ,' pl. iv fig. 7.

sarcode save in the exceptional form *Myxobrachia*. In that genus, however, small calcareous bodies are to be found collected towards the ends of its depending processes. These bodies closely resemble the coccoliths and coccospheres which have been found so extensively at the bottom of the sea. It seems to me not improbable that these bodies are the remains of food; and that the same may be the case with "minute echinated calcareous

Fig. 4.



Myxobrachia pluteus. *a*, extracapsular alveoli; *b*, capsule; *c*, nuclear vesicle; *d*, gelatinous substance; *f*, coccolith-like concretions at the end of the arm-like processes. (After Haeckel.)

spheres, looking like the rowels of spurs," described as scattered irregularly in the gelatinous outer substance of *Calcaromma calcarea*, a new form noticed and figured by Sir C. Wyville Thomson*.

Certain peculiar structures already mentioned (the "yellow cells") are very characteristic of the Radiolaria, being found in all except some *Acanthometra* forms, though their number is very inconstant in the same species†. They are nucleated, and their yellow protoplasmic contents, which contains starch-granules, is enclosed in a distinct membrane.

* 'Voyage of the Challenger,' vol. i. pp. 232–33.

† See representations in Archiv für mikrosk. Anat. vol. vii. pl. 29. figs. 30–36.

Scattered round the capsule, they, in the complex forms, often wander some distance into the circumcapsular gelatinous mass.

Hertwig * deems it probable that they arise from nuclei which pass out from within the capsule; but there is no evidence for this; and Cienkowski † having found them vigorously multiplying in dead Radiolaria, suspects that they may be parasitic organisms. This latter view is opposed by Hertwig on account of the great constancy of their presence in almost all Radiolaria. But undoubted parasites are present with remarkable constancy in many higher animals, while several difficulties disappear if we may regard them as parasites. It would, first, account for no other satisfactory explanation of their origin having been arrived at; secondly, for their greatly varying number; thirdly, for their survival and increase amidst the decomposition of the individuals in which they live; and, lastly, it would explain the anomaly of their existence in such creatures as Radiolaria—*i. e.*, the anomaly of unicellular animals containing true cells within them. For the yellow cells are undoubted cells multiplying by spontaneous division of their cell-contents, each division surrounding itself by its own cell-wall before the dissolution of the mother cell. Their size varies from about 0·005 millim. to about 0·025 millim.

Certain yet other extracapsular bodies have been noticed by Hertwig ‡ in *Collozoum inerme* surrounding the central capsules, but also wandering far from them into the gelatinous investment. They are mostly spheroidal, and from 0·02 millim. to 0·04 millim. in diameter, though they may be more elongated. Each contains small fat-particles, and osmic acid brings also into view some large nuclei. The nature of these bodies is problematical; but it is not impossible that they may be new central capsules in an incipient stage of existence. They may, however, be stages of the reproductive process, in considering which they will be again referred to.

* 'Histologie,' p. 19.

† Archiv für mikrosk. Anat. 1871, vol. vii. He also tells us that yellow-coloured specks, which might be taken for young yellow cells, were due to the Radiolarian observed having fed on yellow *Tintinnoids*.

‡ *L. c.* p. 37. He considers that Haeckel's "extracapsularen Oelkugeln" (p. 149, pl. xxv. fig. 13) may be the same bodies (though they are less regular in form and more numerous than Haeckel's), as also Müller's "sehr kleine Nester" (Abhandl. Berlin, 1858, p. 5) and Cienkowski's "zusammengedrängte Bläschen" (Archiv f. mikrosk. Anat. vol. vii. 1871, p. 378, pl. xxix. fig. 29), which looked quite like young capsules.

Finally to be noticed amongst the soft parts is that mass of delicate sarcodic prolongations, the pseudopodia. These radiate from the deepest part of the extracapsular mass, passing between the alveoli where these are present, and perforating the gelatinous investing coat. They radiate in all directions; and thus in the compound forms the pseudopodia of all but the superficial zooids, and the inwardly directed pseudopodia of even the superficial ones, pass into the soft mass, between its included alveoli. In those single forms, however, which have a bilateral symmetry, the pseudopodia radiate accordingly, and are commonly longest and most numerous from the long axis of the body. They may even stream forth from the ends only, as in *Diploconus*; and when the skeleton forms a conical shell with special apertures at its base, it is in the latter situation that the pseudopodia are longest.

The pseudopodia, like those of the Heliozoa, have generally much persistency of direction and little flexibility. Nevertheless they may bend much and can be retracted, an action distinctly observed by Hertwig in *Thalassicolla*. In some species granular particles of the sarcode may be plainly discerned slowly streaming to and fro along the pseudopodia.

These processes appear to branch in some species and not in others and similarly they may or they may not anastomose. In some forms they traverse hollow canals enclosed within parts of the skeleton, appearing at the apices of the spines thus perforated.

Their number is generally great, over a thousand in an individual *Thalassicolla*. On the other hand, they may be so few that their number may serve as a distinctive character, as in *Acanthometra*. Their length may more or less exceed the diameter of the body, as in *Ethmosphæra* and others, or scarcely equal to a quarter of that diameter, as in *Trematodiscus* and *Spongocyclia*.

In a few bilaterally symmetrical genera (*Euchitonia*, *Spongocyclia*, and *Spongastericus*) there is a *flagellum* attached to the middle of one end of the body. It is formed of homogeneous sarcode, and is much thicker than the pseudopodia, which it may but very little exceed in length, though it may much exceed them. It has the form of a very elongated cone, and is generally bent in a double flexure instead of being straight like the pseudopodia. It appears to move slowly.

In *Acanthometra* and its allies the sarcode, after death, becomes retracted, so as to form blunt prominences corresponding to the

sheaths of sarcode which in life envelop the spines to their apices. At the summit of each such blunt prominence there is a circle of small papillæ, which consist of the remains of the retracted pseudopodia.

As has been said, a system of internal hard parts is more or less developed in almost all Radiolarians. The few yet known utterly devoid of a skeleton are the simple forms *Thalassicolla*, *Thalassolampe*, and *Myxobrachia**, and the compound form *Collozoum*. The skeleton consists generally of silex only, and is never calcareous †. In some forms, however, it consists only of a peculiar cartilaginous animal substance "*acanthin*" ‡. In some forms this acanthin becomes, with age, more or less replaced by silica.

The form of the skeleton varies greatly, from extreme simplicity to extreme complexity. It may be described as consisting of two systems of parts :—

A. A system of circumferential (tangential) parts ;

B. A system of radiating parts.

Either of these may exist (alone or with the other) in different degrees of development, from the most rudimentary condition up to an extreme degree of complexity.

These parts may also both exist in so fragmentary a state and in such a complex entanglement, as to form a spongy skeletal network which may coexist with simpler parts of either of the two skeletal systems or by itself alone. Thus the spongy network, if it were considered a third kind of skeleton, might be said to pass gradually either into the circumferential or into the radial system of parts.

Both systems of parts may exist, in different groups of Radiolarians, either externally to or more or less within the capsule, or both within and without it simultaneously.

Both the circumferential and the radial parts may be either

* I do not regard the calcareous formation found in this genus as skeletal.

† Sir C. Wyville Thomson has (as before noted) described shortly and figured a Radiolarian, *Calcaromma calcarea*, in which calcareous spheres like "the spicules of a Holothurian" were found. Until we have more detailed information, I hesitate as to the truly skeletal nature of these calcareous particles. See 'Voyage of the Challenger,' vol. i. p. 233, fig. 51.

‡ A substance much like keratin. It is eaten into and destroyed by sulphuric acid.

solid or, more rarely, hollow; and in the latter case they are traversed by the sarcode.

The circumferential system appears, in its most rudimentary condition (in the simple form *Physematium* * and the compound form *Sphærozoum italicum* †), as short, separate, solid, needle-like, but more or less curved spicula. They are placed tangentially around the capsule. Some of those of *Physematium* exhibit the next degree of complication in that they give off at intervals and at right angles short pointed processes.

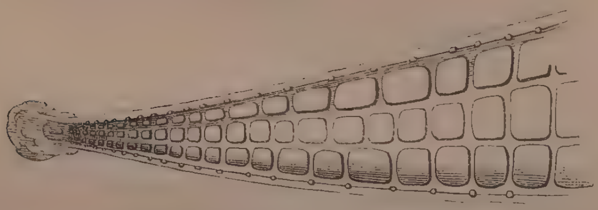
A step further is shown in the exceedingly long and delicate, but hollow spicules of *Aulacantha* ‡ and *Thalassoplaneta* §. Those of the former genus are so numerous and relatively minute as to form an investing layer towards the outside of the extracapsular sarcode with its large alveoli. Those of the latter genus are of enormously greater size relatively.

Next comes the compound genus *Rhaphidozoum*, round the capsules of which we find simple spicula, like those of *Sphærozoum italicum*, but with short secondary processes (like the more complex of those before mentioned as occurring in *Physematium*); and, in addition, other spicula, each formed of four such needles radiating from a common point ‖.

Another step in advance, as regards complexity, is by the compound species *Sphærozoum ovo-di-mare* ¶, where each spiculum is in the form of a short rod which subdivides at each end into three radiating processes, and these may be provided with secondary processes, as in *S. punctatum* **.

We have seen that the needle-like spicula of *Aulacantha* are so numerous as to form a disconnected investment and network of

Fig. 5.



Cornutella scalaris. (After Ehrenberg.)

* See 'Radiolarien,' pl. iii. fig. 9.

† *L. c.* pl. xxxiii. fig. 2.

‡ *L. c.* pl. ii. fig. 1, and pl. iv. figs. 4 & 5.

§ *L. c.* pl. iii. fig. 13.

‖ *L. c.* pl. xxxii. fig. 11.

¶ *L. c.* pl. xxxiii. fig. 6.

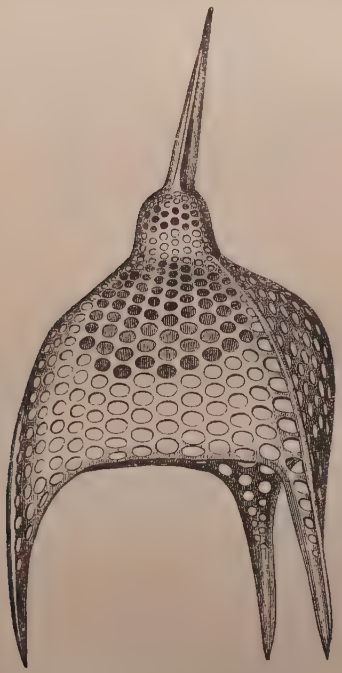
** *L. c.* pl. xxxiii. fig. 7.

detached parts. Now if we conceive these to be united together into one complex structure, we may thence derive all the other forms of circumferential Radiolarian skeletons. First, by union in an irregular manner, we obtain a spheroidal investing network with irregular intervals, as in *Cyrtidosphæra* and *Collosphæra*.

Secondly, let these be united with regularity, and we get such a form as *Heliosphæra inermis* * (the skeleton of which consists of bars enclosing equal-sized and perfectly regular hexagonal spaces); and if the skeletal parts be hollow, we get such a structure as *Aulosphæra elegantissima* †.

Thirdly, let the intervals of the network be greatly reduced in relative size, as sometimes in *Collosphæra* ‡, and the sphere be

Fig. 6.



Dictyopodium, sp.? (After Wyv. Thomson.) §

* *L. c.* pl. ix. fig. 1. † *L. c.* pl. xi. fig. 6. ‡ *L. c.* pl. xxxiv. fig. 4.

§ I herewith take the opportunity of acknowledging the kindness of Prof. Sir C. Wyville Thomson and Messrs. McMillan & Co., in allowing me the use of woodcuts fig. 6 and fig. 8 hereafter represented. Both these have already appeared in the 'Voyage of the Challenger.'

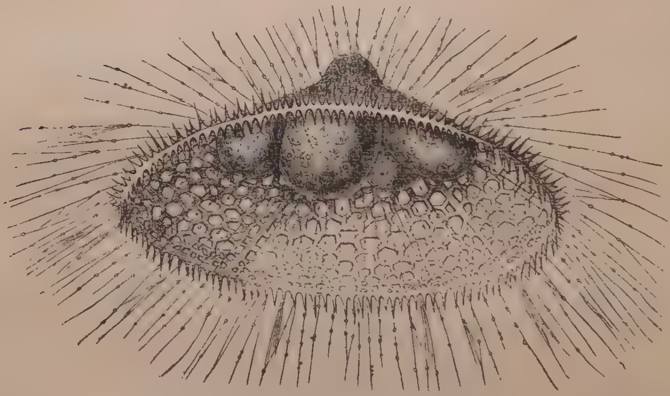
drawn out at opposite poles and be irregularly constricted meridionally and equatorially, and we get such a form as *Botryocampe*, one of a series of Polycystinian forms.

Let this be open at one pole, and we get such forms as *Eucyrtidium*, *Cyrtocalpis obliqua*, and *Cornutella* (fig. 5).

Let the margins of the open end be produced into spines, and we get such forms as *Lychnocanium* and *Dictyopodium* (fig. 6).

Let one pole be greatly expanded and we have *Eucecryphalus*,

Fig. 7.



Eucecryphalus Schultzei. (After Kölliker.)

and finally we have *Litharachnium tentorium*, which latter exhibits, in the delicacy of its skeletal bars, a return towards the circumferential network of *Aulacantha*.

Fourthly, let the circumferential skeleton, as it is in *Cyrtidosphæra*, be conceived as having its apertures greatly reduced and its solid parts augmented in massiveness while they are reduced in number, and we get such forms as *Zygostephanus* *, *Dictyocha* †, and *Acanthodesmia*.

But the circumferential skeleton may not only form a single layer investing the capsule, for there may be two, three, or even six more or less completely developed skeletal spheres concentrically investing the capsule, as in *Arachnosphæra*. These complex concentric structures, however, are intimately connected with and more or less dependent upon radiating skeletal elements, so that they will be best considered along with the radiating structures referred to.

* *L. c.* plate xii. fig. 2.

† *L. c.* plate xii. figs. 3-6.

All the skeletal parts yet treated of are placed without the capsule; but a circumferential skeleton may exist within, or simultaneously within and without it.

Thus we may have a spheroidal shell with small perforations as in *Cœlodendrum**, and this may be accompanied with one (*Heliodiscus*†) or two (*Actinomma*‡) other concentric shells external to it.

The circumferential skeletons hitherto considered have been more or less nearly spheroidal; but they may be (as in the *Discida*) so compressed as to form flat, rounded, or elliptical disks, the opposite sides, however, being generally more or less convex, so as to make the whole shell to a greater or less degree lens-shaped. These shells, however, are not merely circumferential, but have a skeletal partition dividing their interior into two by a transverse partition, which extends everywhere to their margins; and thus they will be better considered when we have entered upon the second or radial system of skeletal parts, to which we may now proceed.

With the second or *radiating system of parts* we have already unavoidably made some acquaintance in considering the circumferential skeleton. Thus in *Botryocampe*, *Eucyrtidium*, *Eucecryphalus*, *Dictyopodium* §, *Dictyocha*, *Zygostephanus*, and *Acanthodermia* we have seen certain centrifugal spines radiating from the surface of the shell.

The pure and simple radial system is, however, to be seen at its simplest in *Plagiacantha*, where the point of union of the radii does not lie within the capsule but eccentrically beside it.

Next may be mentioned the long spines of *Aulacantha*‖, which are hollow with numerous barbs towards their apices, and which impinge by their proximal ends against the outside of the capsule. Also the barbed spines of *Aulosphæra elegantissima*¶, which spines radiate from the points of junction of the circumferential hollow bars which form its beautiful and symmetrical investing shell before noticed.

From the outside of a circumferential shell long spines may radiate in all directions, and from such spines fibres may be given off at regular and coinciding intervals, which fibres may, by their junction, form as many as six delicate concentric spheres, succes-

* *L. c.* pl. xiii. fig. 3. † *L. c.* pl. xvii. figs. 5–7. ‡ *L. c.* pl. xxiii. fig. 6.
§ See *antè*, fig. 6. ‖ 'Radiolarien,' pl. iv. fig. 2 & 3. ¶ *L. c.* pl. xi. fig. 5.

sively investing the innermost but extracapsular shell from which such radii start. This condition is seen in *Arachnosphæra myriacantha*, and has been already referred to as occupying circumferential structures depending upon radial parts.

The radial parts hitherto referred to are all extracapsular; but radii may proceed from an intracapsular spheroidal shell, as in *Heliodiscus** and *Actinomma*, and also in *Rhaphidococcus*†.

They may so radiate and at the same time assume the most beautiful arborescent structure, which may be solid, as in *Cladococcus*‡, or hollow, as in *Cœlodendrum*.

Fig. 8.

Xiphacantha obtained during the 'Challenger' Expedition §.
(After Wyv. Thomson.)

The truly radiating structure *par excellence* is found, however, in *Acanthometra* and the allied genera, where we often find radii only, with no vestige of a circumferential skeleton. The radii

* *L. c.* pl. xvii. figs. 5–7. † *L. c.* pl. xiii. fig. 5. ‡ *L. c.* pl. xiv. fig. 6.
§ 'Voyage of Challenger,' p. 235, fig. 53.

may or may not be of similar length, but they always meet within the capsule and consist of twenty acanthin spicula.

They may merely meet together centrally, and be all alike, as in *Acanthometra.*

On the other hand, the differences in their length and size may be so great as to make the body conspicuously bipolar, as in *Amphilonche*, where two spicula are greatly in excess of the others.

Four spicula may be in excess, to a less degree, forming two long axes at right angles, as in *Acanthostaurus**.

Moreover the processes may give forth transverse processes, as in *Xiphacantha* (fig. 8); and these processes may be very complex, as in *Lithoptera*†.

The spicula may not merely meet together, but they may ankylose together centrally, as in *Astrolithium* and *Staurolithium.*

Two other very exceptional conditions may obtain:—(1) The spicula may merely adjoin when they meet, but instead of regularly radiating on all sides, may all be directed one way, diverging irregularly from one polar axis, as in *Litholophus*‡.

(2) The spicula may be ten in number, and go right through the central capsule in all directions, each spiculum perforating the capsule's wall in two places, the spicula meeting but not in any way uniting centrally.

But radial elements may either join or both join and ankylose, when one or more circumferential shells also exist, the radii perforating them and either simply joining or ankylosing together in the centre, as in *Dorataspis*, *Halliommatidium*, and *Aspidomma.*

One of the most peculiar of all Radiolarian shells is that of *Diploconus* §, where we have two very large polar spicula (as in *Amphilonche*) united with ten short, cylindrical, radiating spicula in the middle of the capsule by absolute ankylosis. To this structure there is added two siliceous homogeneous cones, with their apices coinciding with the central mass and with serrated margins at the open ends, from the middle of each of which protrudes one of the large polar spicula. Each of these cones may be conceived as formed of diverging spicula (like those of *Litholophus*) united together; and thus *Diploconus* would be like *Litholophus*, with a double set of opposite, modified, and fused-together spicula, to which other ankylosed spicula, like those of *Amphilonche*, are added.

* *L. c.* pl. xix. fig. 5.
† *L. c.* pl. xx. fig. 1.
‡ *L. c.* pl. xix. fig. 6.
§ *L. c.* pl. xx. fig. 7.

We may now consider those Radiolarian skeletons which were before spoken of as more or less flattened or lens-like capsules, each with a median partition. Such median partition may be taken as representing the radial elements of the skeleton, and the outer shell, of course, as the circumferential portion.

As before said, the transverse partition extends everywhere to the united margins of the two external halves of each shell; and thus there comes to be on each side of the median partition a cavity bounded externally by the concave surface of one of the two external plates; these plates are irregularly perforated; while the internal median partition may consist of a number of concentric rings united together at regular intervals by radiating centrifugal bars of similar size to the concentric rings, as in *Trematodiscus*.

These structures may include a spheroidal shell within them, or even three concentric shells of the kind as in *Coccodiscus* *.

The shell may be like *Trematodiscus*, except that it is produced on three sides into three arm-like prolongations, as is the case in *Euchitonia*; and these arms may be further united by an extension of similarly formed shell between them, which extension increases with age.

The shell may have four very elongated arms, as in *Stephanastrum* †.

Instead of the median partition being formed of a number of concentric rings, it may be so formed that the parts representing such rings may take the form of a continuous spiral band, starting from the outside of a very small centrally placed ring. This is the case in *Stylospira*.

Finally, the maximum condition of complexity, with a special arrangement of parts, is attained in *Lithelius*. To understand this shell, which is spheroidal, or an elliptical spheroid, we must imagine a shell, like that of *Stylospira*, made so convex on each side that the whole is nearly spherical. Simultaneously with this change the central partition must be widened out on each side so as to fill up the hemispherical vacuity which would otherwise exist on each side of it; but the continuation of the centrifugal and circumferential bars must not be imagined to form solid partitions, but to be perforated on each side of each cavity, so as to place all the adjacent chambers in mutual communication. Thus would be produced a set of chambers (all opening into adjacent

* *L. c.* pl. xxviii. figs. 11 & 12.

† See Ehrenberg, Abhand. k. Akad. Berlin, 1875, pl. xxv. fig. 1.

chambers on all sides) winding spirally round an axis placed at right angles to the plane of the original median partition, which we have ideally enlarged.

Another mode of conceiving the structure of this shell is to first conceive a central hollow die with successive series of hollow dice placed, one set outside the preceding, all round it so as to form one whole. Secondly, to imagine these dice to have their surfaces cut in curves so that they may be mutually adjusted, and thus form a sphere of successive concentric layers of hollow dice. Then to imagine each die to have a perforation made in each face (six, of course, to each), the perforations of adjoining dice corresponding in position so as to place their hollow interiors in communication—successive concentric layers of hollow communicating chambers being thus produced. Finally, we must imagine a slight twist to be given to the complex whole, so that instead of concentric layers we may have a spiral arrangement of the chambers and of their perforated separating walls, which would thus have come to wind round a single longitudinal axis.

We come now to that system of confused and confounded radiating and tangential parts which together form the spongy kind of skeleton.

The entire skeleton may consist of this kind of structure exclusively and be discoidal, as in *Spongodiscus* *, or cylindrical with radiating spines attached, as in *Spongurus* †.

The spongy tissue may include a concentric shell like that of *Trematodiscus*, as is the case in *Spongocyclia* ‡, or surround two or three concentric shells, as in *Dictyosphagma* § and *Spongodictyum* ‖ (or *Dictyosoma*).

But not only concentric spheres, but also strong radii proceeding from their exterior may coexist with a spongy mass, as in *Spongosphæra* ¶.

Finally, a spongy mass may lie entirely outside the capsule and be connected with two spheroidal intracapsular concentric shells by means of radial spines, as is the case in *Rhizosphæra* **.

Such are the main forms presented by the skeletons of the Radiolaria which are as yet known.

Before leaving this portion of my subject, I may be permitted to remark that to my mind it seems evident that these beautiful,

* *L. c.* pl. xii. figs. 14 & 15.
† *L. c.* pl. xxvii. fig. 1.
‡ *L. c.* pl. xxviii. fig. 2.
§ Abh. k. Ak. Berlin, 1858, pl. ii. figs. 9–11.
‖ 'Radiolarien,' pl. xxvi. figs. 4–6.
¶ *L. c.* pl. xxvi. figs. 1–3.
** *L. c.* pl. xxv. figs. 1–10.

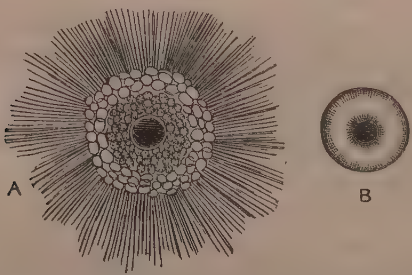
symmetrical, and complex forms cannot be due to the action of *natural selection*, and *sexual selection* can of course take no part in forming such organisms as these. We seem here to have forced upon our notice the action of a kind of organic crystallization, the expression of some as yet unknown law of animal organization, here acting untrammelled by adaptive modifications or by those needs which seem to be so readily responded to by the wonderful plasticity of the animal world.

Impressionability, Locomotion, and Nutrition.

The life-processes of the Radiolaria are similar to and are carried on by similar means as those which exist in the *Polythalamia.* Except in the existence of a central capsule and of yellow cells (the nature of which is so doubtful), nothing in the shape of organs is perceptible; and the granules or other matter found within the sarcode can circulate freely throughout its substance. Yet there is some evidence that this structureless sarcode ministers to a certain appreciation of light, since Professor Haeckel found that in a few hours these organisms would cross and recross a glass vessel in order apparently to reach its more illuminated side. Possibly, however, as the Professor himself remarks, this movement may have been really due to currents setting in towards the warmer (which was of course the lighter) side of the vessel.

Radiolarians also seem sensible to heat, since in hot weather they descend to cooler strata of the sea instead of remaining close to the surface, as in weather less warm. They also show, as might

Fig. 9.



Thalassicolla nucleata. A. Showing the alveoli expanded and the pseudopodia protruded. B. Contracted. (After Hertwig.)

be expected, sensibility to touch, in so far as they withdraw their pseudopodia and contract their bodies upon the occurrence of any

slight shock, while upon the return of tranquillity they resume their expanded condition; and Hertwig has not only found this to be the case, but also that the external alveoli will close up and disappear with the body's contraction.

Very slight pressure also interrupts the flow of that protoplasmic current and granule circulation which normally exists.

The pseudopodia are never drawn back within the capsule, as is evident by the volume of the capsule remaining constantly the same, though its form may change in some compound Radiolarians.

The animals are very delicate, and are mostly killed by the mere act of catching them in a net. The Polycystine forms are most often taken in a living state; but the Acanthometrine forms are generally dead when captured. In order to keep these animals any time alive, the water in which they are must be kept pure and changed daily and considerable space must be allowed to each animal. Haeckel found the Acanthometrine forms to be the most sensitive and delicate, and these qualities to decrease serially in the following groups:—(1) *Sphærozoida*, (2) *Collosphærida*, (3) *Cladococcida*, (4) *Collida*, (5) *Cyrtida*, (6) *Ethmosphærida*, (7) *Ommatida*, (8) *Spongida*, and (9) *Discida*.

The *motions* manifested by the Radiolaria are like those shown by the Polythalamia, but weaker, slower, and less obvious. Motion seems to be confined to the extracapsular sarcode, though the capsules of some compound species have been observed to change their shape. The motions are produced by granule streams, as in the Polythalamia. But these do not result in creeping movements as in them, inasmuch as the Radiolaria are essentially floating organisms, and generally have their pseudopodia far extending on all sides. It is a problem how they effect this swimming motion, since their specific gravity is greater than that of water. It is possible they may overcome gravity by active motions of their pseudopodia, or by expanding them distally at the surface of the water so as to act as a sort of float. The contraction and expansion of the alveoli would explain the rising and sinking of such forms as *Thalassicolla*; but, then, most Radiolaria have no alveoli. They can move on solid surfaces by successively contracting their pseudopodia after adhesion, an action which has been observed by Haeckel in his *Collida*, *Cyrtida*, *Ommatida*, and *Discida*. The pseudopodia may ramify, then broaden out at their ends and apply themselves to an object, over which the Radiolarian rolls itself by

successively contracting such applied pseudopodia, just as an *Echinus* rolls itself over by contracting serially its adhering ambulacral suckers. Many Radiolarians also resemble *Echinus* in that they use their spines as levers. Haeckel has observed a *Lithomelissa* (a Polycystine form with spines round the mouth of its shell) thus raise itself so as to apply the mouth of its shell to the floor.

These creatures nourish themselves in the same manner as do the Polythalamia, but with less rapidity and energy. Moreover, in Radiolarians the food does not reach the middle of the body (as it does in Polythalamians), on account of the capsule, which Haeckel never observed to be traversed by any particles of carmine or indigo supplied for experiments.

They live on Algæ, Diatoms, and Infusoria (especially on *Tintinnidæ*), and other small animal and vegetable organisms found near the surface of the sea. Haeckel has observed Infusoria to become paralyzed by the touch of the pseudopodia of *Aulacantha* and *Thalassicolla*, a fact pointing to the existence in undifferentiated sarcode of a power and property which becomes energetic in the thread-cells of Cœlenterata and other less lowly animals. The food is absorbed into any part of the extracapsular sarcode which the skeleton does not hinder it from reaching. They probably also absorb organic matter dissolved in the sea-water. Very minute objects may often be observed coursing centripetally along the pseudopodia, together with the granule-streams. When the prey is relatively large many pseudopodia surround it, draw it in and close over it; and thus food can be assimilated by the pseudopodia themselves when the formation and condition of the shell prevents its penetration more deeply within the matrix.

Haeckel speculates as to the possibly hepatic nature of the yellow cells, considering it to be not unlikely that they may be an incipient form of liver. But, in the first place, these cells may (as has been said) be parasitic; and, secondly, a liver is, as it were, a comparatively late result of tissue-formation, and could hardly exist in the admittedly tissueless Protozoa.

Abundant silica is manifestly somehow obtained by Radiolarians, either from the sea-water itself or from their Diatomaceous food; and there must be a free interchange of nutritious matter through the capsule (even if solid food does not pass through it), as, in so many, part of the siliceous skeleton is intracapsular. If food *does* ever pass through it, then the existence of the concretions within it may be explicable as food-remnants, as before suggested.

Reproduction and Growth.

The reproductive processes of the Radiolaria have as yet been completely worked out in no individual form, and even the early stages of it have been observed only in *Acanthometra* and *Thalassicolla* amongst the single forms, and in *Sphærozoum*, *Collosphæra*, and, best of all, in *Collozoum*, amongst the compound forms. What has been hitherto observed, however, in these different genera is of so similar a character that it seems reasonable to anticipate the existence of similar first stages in Radiolarians generally.

The first observation was made by John Müller in 1856*, who saw inside an *Acanthometra* (apparently within its capsule) a mass of small Monad-like vesicles in motion, which gave off some very delicate filaments "like those of *Acanthometra*."

In 1858, Schneider† saw moving vesicles inside the capsule of a *Thalassicolla*, the vesicles being provided with protruding and retractile processes and also with flagella.

In 1859, Haeckel‡ discovered that the content of the capsule of *Sphærozoum* breaks up into vesicles, which he observed to vibrate, but he did not notice any flagella. He noticed, however, that the several vesicles each contained within it a whetstone-like crystalline body, such as had been previously found amongst the intracapsular sarcode of the same species. On this account and on account of its supposed exclusion from the digestive process, Haeckel suspected the central capsule to be the generative organ, as Müller, for a time, thought the yellow cells might be.

In the same year he found §, in *Acanthometra tetracopa*, five small bodies like young *Acanthometræ*; but as he found no others in hundreds of *Acanthometræ*, and as they were not observed till after the crushing of the capsule, he suspected that they might have been merely adherent to it and not have come from within it.

Young *Acanthometræ* have the spines only imperfectly developed‖, sometimes only eight, and scarcely perforating the capsule or even being as yet quite within it.

As to the compound forms, Haeckel believed that their capsules increased not only by fission but also endogenously; and he also believed that individuals separate themselves and lay the foundation of fresh colonies, for he often found single capsules of *Sphærozoum* and *Collozoum*. He never observed the actual fission of any colony, yet such fission seemed indicated by the beaded (appa-

* Abhand. d. k. Akad. Berlin, 1858, p. 14. † Müller's 'Archiv,' 1858, p. 41. Radiolarien,' p. 141. § *L. c.* p. 144. ‖ *L. c.* pl. xv. fig. 7.

rently incipiently segmented) form of many colonies (fig. 1, p. 138). Multiplication of capsules by fission he believed to be general in the compound kinds, and it seems to take place irregularly in most species. In *Collosphæra*, however, it can only take place in the young shelless condition found in the middle of the colony, since in the developed capsule the shell would hinder subdivision.

Sometimes shells of *Collosphæra* are found in such a condition as to indicate that they were formed while fission was in progress, a shell sometimes appearing like two shells not quite divided off one from another.

Haeckel also found a *Thalassoplaneta* with two capsules within it*, and doubted whether the circumstance might not be an instance of the beginning of a colony†; but he decided against this view‡, because of:—(1) the absence of alveoli, present in all known compound forms; (2) the presence of extracapsular pigment-heaps (as in *Aulacantha*, *Thalassicolla*, and *Cœlodendrum*); (3) the presence of hollow spines, also present in the three genera last named; and (4) the finding of a single capsule dead.

Most noteworthy is the fact that he saw § the contents of *Collozoum* capsules break up into internal masses with oil-globules, one in each, or with one large one in the middle of the divided masses. This he considered as endogenous capsule-formation; but (as we shall see) it may have been an incipient stage of spore-formation.

Haeckel also found oil-globules to be sometimes scattered in the extracapsular sarcode, especially in small colonies in January and February.

In 1871, Cienkowski found ‖ that the contents of the capsules of *Collosphæra* resolved themselves in twenty-four hours into delicate vesicles, which again broke up into little spheroids ¶.

In colonies the capsules of which are so filled, the corpuscles collect together, the alveoli disappearing, and the contents of the capsules begin to move and ultimately swim away as zoospores, passing through the holes of the shell, the ripening, however, of the different capsules not being synchronous.

* *L. c.* pl. iii. fig. 10.

† This circumstance, as well as the separate capsules of *Sphærozoum* and *Collozoum* sometimes found, much reduces the importance of the distinction between the single and compound conditions of Radiolarian life.

‡ *L. c.* p. 262.

§ *L. c.* p. 148.

‖ Archiv f. mikrosk. Anat. vol. vii. p. 372 (1871).

¶ Archiv f. mikrosk. Anat. vii. pl. xxix. figs. 5, 6, & 10, and 'Quarterly Journal of Microscopical Science,' (new ser.) vol. xi. pl. xviii. figs. 5, 6, & 8.

Each zoospore is oval, ·008 millim. long, and is provided with two long cilia. Each also contains a crystalline rod and a few oil-drops*. Other zoospores were noticed which were angular and without cilia, apparently immature†. After twenty-four hours all the zoospores died and dissolved away. These zoospores were probably identical with the swarming vesicles found by Haeckel in *Sphærozoum.*

In *Collozoum* Cienkowski found the capsules multiply by division ‡, and containing often small crystalline rods as well as oil-globules; but he deemed the occasional presence or absence of these rods as a matter of no importance. He found the contents of each capsule to break up into wedge-shaped or spheroidal masses §, which then divided into small spheroids. As in *Collosphæra,* so also here the colonies at this stage lose their alveoli, while their capsules cohere and press together. Illness prevented Cienkowski pursuing the investigation further; but his observations confirmed Haeckel's as to young capsules being naked, having, in fact, no central capsule.

With a view to seeing whether yellow cells would produce themselves spontaneously, he followed Schneider in extruding *Thalassicolla*-capsules from their investing-mass. The capsules so extruded developed themselves only so far as to produce pseudopodia. He found, as before stated, yellow cells freely multiplying themselves in the dead body of a *Collozoum* colony.

Schneider found ‖ that he could keep *Collozoum* five or six days in a cool temperature and by changing the water daily. He also found that upon dividing a colony each part survived and rounded itself off, and that two colonies placed in juxtaposition became fused together in about twelve hours. The soft parts of two adjoined *Thalassicollæ* seemed to fuse together.

Hertwig has published ¶ by far the most complete and detailed account of the Radiolarian reproductive processes; but even he failed to keep the zoospores alive, so that we still remain ignorant of the stages which may intervene between the zoospore larval stage and that which approaches the mature condition.

* Archiv, *l. c.* figs. 11 & 12, and Quarterly Journal, *l. c.* figs. 9 & 10.

† Archiv, *l. c.* figs. 16 & 17, and Quarterly Journal, *l. c.* figs. 14 & 15.

‡ Archiv, *l. c.* figs. 25–28, and Quarterly Journal, *l. c.* figs. 20–23.

§ Archiv, *l. c.* figs. 20 & 21.

‖ Reichert und Du Bois Reymond's Archiv, 1867, p. 509.

¶ 'Zur Histologie der Radiolarien,' Leipzig, 1876.

Hertwig considers the capsule of *Collozoum* to be a multinucleate cell or syncytium, and agrees with Schneider in thinking that it answers to that part of the sarcode of a Foraminifer which lies within the shell. He considers, therefore, that it is not "an organ," and certainly not a "generative organ."

He says that the capsules multiply themselves by division; but he denies that Haeckel was right in considering the multiplication of contained oil-globules to be a sign of the process, as it occurs also in the beginning of zoospore-formation.

He thinks, however, that capsule-division is preceded by multiplication of nuclei, because in a dividing biscuit-shaped capsule he found at each end of it a heap of nuclei equal to the entire mass of nuclei contained in the smallest single capsules. He does not accept Haeckel's inferred process of endogenous cell-formation, but deems the appearances seen by Haeckel to be really due to different progressive steps in one process of zoospore-formation.

New colonies, he tells us, may more or less certainly be formed in three ways:—

(1) Probably by fission, inferred from the chain-like aspect of some colonies, as before stated.

(2) Possibly by the separation of small portions—a process the existence of which was suspected by Müller and Haeckel from the finding of single capsules devoid of alveoli.

(3) Certainly by zoospore-formation.

It appears to take a capsule several weeks to become ripe for zoospore-formation, and there seems to be various individual peculiarities in the process.

Cienkowski noticed in *Collozoum*, as before said, that some capsules contained crystalline rods within them, while other capsules did not contain any such bodies. Harmonizing with this, the specimens of *Collozoum* examined by Hertwig showed two different kinds of zoospore-formation, one with, the other without crystals.

Zoospores with Crystals.

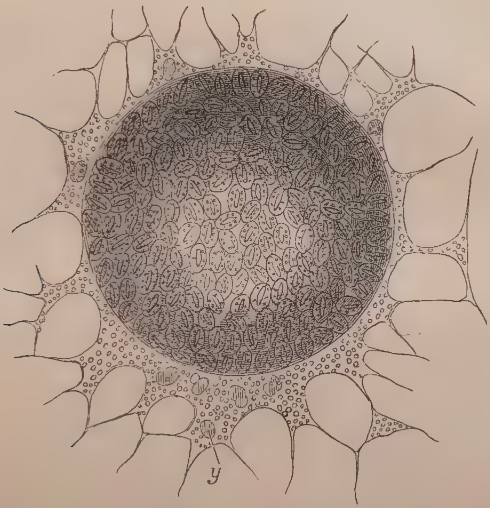
In this kind of reproduction we have in the first stage small capsules containing good-sized nuclei, which subdivide and become heaped together medianly, leaving a space, containing oil-globules, between them and the capsular membrane*. Then fatty granules and whetstone-like crystals become distinguishable, the crystals

* Hertwig, pl. i. fig. 1.

having rounded edges and angles with an organic appearance, and being insoluble in both acids and alkalies.

By degrees the crystals, fat-granules, and nuclei become aggregated, so that each capsule is found to contain small bodies, each

Fig. 10.



Contents of a capsule of *Collozoum inerme*, with the bodies above described. *y*, yellow cells. (After Hertwig.)

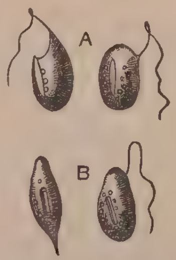
of which consists of a nucleus with a crystal and some fat-granules. The oil-globules have disappeared, having served to form the fatty granules.

At this stage of development the whole colony sinks, the alveoli dwindle and disappear, and the different capsules become aggregated together towards the middle of the mass. At this stage also a colony will fall asunder with the slightest disturbance, the separated capsules bursting and letting out the contained small bodies, which have already began to show a tumultuous motion. When discharged, these small bodies are seen to be zoospores, which are at first lively, but which Hertwig found to die in an hour.

Each of the contained bodies or zoospores is oval, with a single flagellum placed at one end, the motion of which is exceedingly lively, so that it might easily be taken for two flagella; and it is possible that Cienkowski may therefore have been mistaken in attributing two flagella to each zoospore of *Collosphæra*. At that end of

the zoospore to which the flagellum is attached its body appears to be homogeneous for about one third of its whole size. The hinder part of the zoospore contains a whetstone-like crystal, so placed as to extend along the axis of the body, and it is surrounded by fatty granules. In the fresh state no nucleus is to be detected; but the application of osmic acid makes manifest a nucleus filling nearly the whole of the homogeneous part of the zoospore.

Fig. 11.



A. Living zoospores of *Collozoum inerme*, with crystals. B. Zoospores of *Collosphæra Huxleyi*. (After Hertwig.)

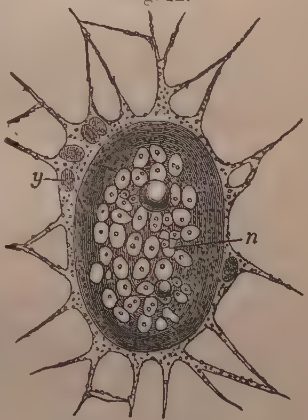
Unripe capsules contain irregular zoospores which are irregular and angular in shape, and are not yet entirely disconnected from each other, but which nevertheless have often a flagellum.

Zoospores without Crystals.

The developmental processes which take place without the formation of crystals seem to be more complex and difficult to understand than the others.

The first stage is quite like that of the mode of development with crystals. In the second stage the nuclei become much divided.

Fig. 12.



Capsule of *Collozoum inerme* without crystals, with oil-globules of different sizes. The nuclei are seen dividing, one (at *n*) into five parts at once. *y*, yellow cells. (After Hertwig.)

This process goes on while certain of the divided parts cohere together to form masses of different sizes, which together fill the capsule, and consist of nuclei with or without a sarcodic investment.

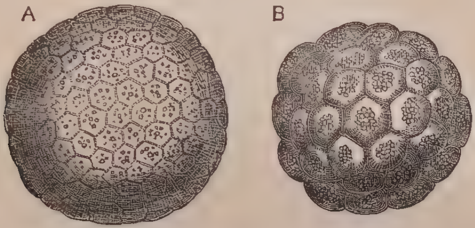
The oil-globules meanwhile may appear in the form of one large central one* or may be numerous and equal-sized, or there may be one large central one with smaller ones around it.

The heaps of aggregated nuclei then grew polyhedric, and ultimately each capsule comes to be filled with aggregated masses of larger or of smaller size, and in a more subdivided or a less subdivided condition. As regards the more finely subdivided masses, each such mass consists

* In Cienkowski's figure no. 21 we have one oil-globule in the middle of each aggregation, as also apparently in Haeckel's pl. xxxv. fig. 12, and we have a single central one depicted in his plate xxxv. fig. 11.

of aggregated nuclei only. As regards the less subdivided masses, each such mass consists of nuclei with sarcode aggregated round each nucleus.

Fig. 13.



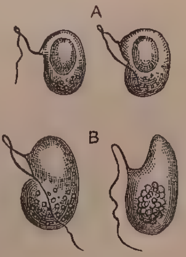
Heaps of nuclei forming masses with different degrees of subdivision in *Collozoum inerme.* A. Mass consisting of nuclei only. B. Mass consisting of nuclei each with a sarcodic envelope. (After Hertwig.)

The masses which thus exist in two states of subdivision have different destinations, or rather different products, respectively. The oil-globules have now disappeared, but instead fat-granules have appeared in the middle of each nucleus.

At this stage the whole colony sinks and the alveoli disappear, just as is the case at a corresponding stage of the development of those forms of *Collozoum* which are provided with crystals. The next change is for each heap of nuclei to break up, and each part (nucleus, or nucleus and sarcode) becomes a zoospore; but, strange to say, the zoospores are of two kinds, *macrospores* and *microspores.*

The aggregations above described as consisting of smaller parts (formed of nuclei only) give rise to the microspores; the macrospores are formed from the less divided masses (formed of nuclei with sarcode round each nucleus). The products bear no relation to the size of the aggregations themselves, but to the size of their component parts.

Fig. 14.



A. Two microspores and B. Two macrospores of *Collozoum inerme.* (After Hertwig.)

Each zoospore consists of a bean-shaped body, with a long flagellum extending from that end of the body where a nucleus can be made plain by osmic acid. Towards the other end of the body there are fat-granules, but there is no crystal. The macrospores are constantly twice the size of the microspores.

As to the meaning of the difference of spores, Hertwig supposes, naturally enough, that it is related to some difference of function.

As to the difference in manner of reproduction with respect to the presence or ab-

sence of crystals, Hertwig always found in *Collozoum* one mode of reproduction only in one colony; and he speculates as to whether there may not be two distinct species which are externally very similar. In support of such specific distinctness, he notices that the forms which are provided with crystals have rounded capsules, while those without crystals have elongated capsules—differences before noticed by Müller. Hertwig concludes from all this that the capsule can be no true generative organ. The nuclei act like true physiological nuclei and attract sarcode around them. The swarming is comparable to a very accelerated cell-division, and he compares it with the free-cell formation of botanists.

In *Collosphæra* and *Sphærozoa*, reproduction takes place, as in the *Collozoa*, with crystals, and each zoospore has a single flagellum.

Thalassicolla breeds by the contents of the capsule dividing and subdividing according as the nuclei contained within it are few or many.

When describing the extracapsular sarcode, certain bodies were referred to as "extracapsular bodies," found by Hertwig in *Collozoum*, and considered by him as perhaps identical with Haeckel's "extracapsulare Oelkugeln"*, and Cienkowski's "zusammengedrängte Bläschen"†, in the same species, and as being, more certainly, the same as the "sehr kleine Nester" found by Müller in *Sphærozoum*.

These structures were described by Hertwig‡ as being peculiar homogeneous bodies, sometimes surrounding the central capsule so as to cover it, but movable and occasionally wandering, through the extracapsular sarcode, from one capsule to another. Of various, often irregular, shapes, and of various sizes, they seem, when fresh, to contain a heap of small fat-spheres; but nuclei become visible when they are acted on by chromic or acetic acid. They never possess any external, limiting membrane, and their contents seem similar to the contents of an ordinary capsule of *Collozoum*.

Hertwig denies, however, that a great resemblance exists between these bodies and the bodies of aggregated nuclei, already described as found within the capsules of *Collozoum* without crystals, the difference being only in shape, and possibly occasioned by the change from an enclosed to a free condition. He is therefore disposed to regard them as such reproductive masses which have escaped from their capsule before breaking up into zoospores,

* 'Radiolarien,' p. 149, pl. xxxv. fig. 13.
† Arch. f. mikrosk. Anat. vol. vii. 1871, p. 378, pl. xxix. fig. 29.
‡ Abhandl. k. Akad. Berlin, 1858, p. 5.

and to regard their irregular shape as due to incipient divisions, preliminary to such break up.

Thus, as to the whole process, it appears that

(1) With regard to the colonies as wholes, they may perhaps increase by spontaneous fission, or by giving off a single or a few capsules. The existence of these modes of increase has not, however, been actually observed, though it is certain that single capsules (however derived, whether from spores or from segmentation) do exist separately. The colonies may also be increased by juxtaposition, and the mass of an existing colony by the rapid fission of its component capsules, the process taking place centrifugally in the shelled and irregularly in the shelless forms.

It is possible that new young capsules may range themselves round old ones, so producing the above-described "extracapsular bodies," which may, on the other hand, be a stage of spore-formation.

(2) With regard to the capsules themselves, it is certain that they may increase by spontaneous fission into two, three, or more secondary capsules, and that this process may repeat itself indefinitely.

(3) With regard to reproduction by spores, it is certain that such a process occurs in *Acanthometra*, *Thalassicolla*, *Sphærozoum*, *Collosphæra*, and *Collozoum*, and most probably in all Radiolarians.

The spores are formed by the breaking up of the contents of the central capsule into small particles, which become directly transformed into the spores, each spore containing a nucleus and fat-granules, and also a crystalline body when such bodies are found within the capsules in which such spores arise.

Each spore is provided, moreover, with a flagellum, and it is doubtful whether more than one flagellum ever exists to one spore.

The spores may be formed either by the breaking-up of the contents of the capsule directly into them, or by its breaking up into variously shaped masses of various sizes, which again break up into such secondarily formed zoospores. In the latter case (as far as yet observed) the primary cleavage results in the division of the capsule-contents into two sets of masses, the masses of one set being more subdivided than the masses of the other set, which parts respectively give rise to two kinds of spores, microspores and macrospores—bodies having, no doubt, different but as yet unknown functions.

It has been thought, as we have seen, that the same species may have colonies of two kinds—one kind of colony breaking up into spores of two kinds (both without crystals); the other kind of

colony breaking up into spores of one kind only, those with crystals. It is, however, possible that these two processes may indicate two different species which resemble each other greatly, save as to this reproductive process.

Beyond the above described stages, no observations have as yet gone, so that the mode of transition from the zoospore to the capsule stage remains unknown. However, the zoospores have no enveloping membrane, and the young central capsules are in like case. If the latter (capsules) proceed directly from the former, the *Radiolaria* so far resemble the *Heliozoa*; and if the processes observed by Müller as existing in the young enclosed *Acanthometræ* resembled the processes of such organisms as *Actinosphærium*, we have yet another approximation between these two groups of Protozoa.

Modes of Growth.

As to the modes of growth of the Radiolaria, Müller pointed out its three main modes:—(1) the unipolar, (2) the bilateral, (3) the multipolar.

The capsule does not change its shape, but when formed is at once spheroidal, conical, or what not, with or without processes or subdivisions. Thenceforth it only increases in volume.

As to the skeleton, in addition to the three modes of growth above noticed, there must be added that sudden mode of formation, that rapid deposition which seems to take place in the shell of *Collosphæra* (as evidenced by its deposition round capsules in the act of fission) and in the single or in the innermost spheroidal shells of such forms as *Ethmosphæra*, *Cyrtidosphæra*, *Heliosphæra*, *Siphonosphæra*, *Diplosphæra*, *Arachnosphæra*, *Rhaphidococcus*, *Cladococcus*, *Cœlodendrum*, *Haliomma*, *Heliodiscus*, *Tetrapyle*, *Actinomma*, *Didymocyrtis*, *Rhizosphæra*, *Spongosphæra*, *Dictyoplegma*, *Spongodictyum*.

Increase, even in the thickness of the network of the shell when once formed, does not seem to take place; for Haeckel found the bars of *Heliosphæra inermis*, *H. tenuissima*, and *H. actinota* constantly the same in size in different individuals of the same species.

Multipolar growth takes place in the Acanthometrine forms *Sphærozoum*, *Stylodicta*, *Lithelius*, *Actinomma*, &c., and also in the species of spine-bearing Polycystine forms and in the twigs of *Cladococcus*. In these the skeletal parts go on increasing at their apices, or (as in *Sphærozoum* and most Acanthometrine forms) all round also.

Fig. 15.

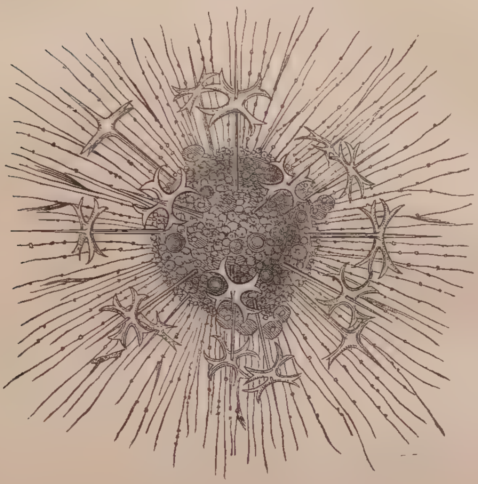


Fig. 16.

Dorataspis polyancistra. Fig. 15. Young. Fig. 16. Mature. (After Haeckel.)

Multipolar growth is also exemplified in such forms as *Dorataspis*, *Haliommatidium*, *Rhizosphæra*, *Diplosphæra*, and *Actinosphæra*. Such shells arise by extension of the skeleton from the radii outwards at right angles, and at similar distances from the centre of the shell, the lateral extensions from such radii meeting to form a sphere by their junctions. In the same way, by the development from each radius of successively diverging structures at similar distances are built up many of the successive concentric spheres before described, *i. e.* of those which coexist with radii.

In *Cœlodendrum* alone of all Radiolaria is constant absorption and redeposition known to take place. It must do so here, as the radiating tubules have always thin walls.

Unipolar growth is exemplified in the Polycystine forms, in which at first the shell is a mere cap placed on the apex of the capsule, and thence growing forth on all sides—in the same way the chambers of such more complex Polycystine forms as *Eucyrtidium*, and probably also those with closed bases like *Botryocampe*, though such have not, so far as I know, yet been discovered in process of formation.

The *bilateral* mode of growth is exemplified by *Haliodiscus* *, in which the outer shell arises as two shields, one on each side of the central shell, each enlarging at its circumference till the two meet.

The *Discida* are formed by a process which may be considered a combination of the bilateral and the multipolar modes. Their median partition is formed by radii which, by the processes they give off at right angles, form the series of concentric or spirally arranged chambers which exist in the median partition and between it and the two outer shields. The two outer perforated plates or shields are formed in the same way as are the bilateral plates of *Haliodiscus*, being, however, nearly quite parallel instead of being much curved as in the last-named genus.

The shells with a spongy skeleton are formed in one or other of the before mentioned ways—in *Spongurus* certainly in the multipolar way.

Distribution of the Radiolaria.

The *Radiolaria* have as yet been found in salt water only, but there very abundantly close to the surface of the sea and at a little depth beneath the surface, whence they descend in cool or cloudy weather. Until quite recently there was no evidence that they

* Müller, Abhand. d. k. Akad. Berlin, 1858, pl. ii. figs. 5 & 6.

also inhabit the deeper parts of the ocean. Haeckel, when off the coast of Sicily, found them disappear from the surface after much disturbance of the water by wind, after prolonged rain (though they do not seem much disturbed by a small quantity of it), or after many days of the sirocco. They seem to be particularly intolerant of dirty water, and delight in a smooth sea and pure transparent water at a moderately warm temperature. The voyage of the 'Challenger,' however, has convinced Sir C. Wyville Thomson* that though Foraminifera are apparently confined to a comparatively superficial stratum the Radiolarians exist at all depths; and he tells us, "in the deposit at the bottom, species occur which have been detected neither on the surface nor at 1000 fathoms, the greatest depth at which the tow-net has been systematically used; and specimens taken from near the bottom of species which occur on or near the surface give us the impression of being generally larger and better developed."

As to their geographical distribution, the same author tells us †, "Radiolarians were met with throughout the whole of the Atlantic, and often in great abundance, the sea being not unfrequently slightly discoloured by them. The forms which appeared in such numbers were usually species of the *Acanthometridæ*, but *Polycystina* and the compound genera were also numerous. The remains of Radiolarians were found in all deep-sea deposits, usually in very direct proportion to the numbers occurring on the surface and in intermediate water. It was frequently observed, however, that when, in deep water, certain species swarmed on the surface, very few of their skeletons could be detected at the bottom. This applies especially to *Acanthometridæ*, and is probably owing to the extreme tenuity of the siliceous wall of their radiating spicules, which may admit of their being dissolved while sinking to a great depth; or probably the spicules may never become thoroughly silicified, but may retain permanently more or less the condition of acanthin. The *Polycystina* seem much less destructible, and occur in abundance on the bottom at the greatest depths. Although the Radiolaria are universally distributed, like the Diatoms, but in a less marked degree, they seem to be most numerous when the specific gravity of the water is low; they specially swarm in the warm and comparatively still region of the south-western Pacific and among the islands of the Malay archi-

* 'Voyage of the Challenger,' 1877, vol. i. p. 236.
† *L. c.* vol. ii. p. 340.

pelago, where they are much more abundant than in any part of the Atlantic."

As to the geographical distribution of different species, little can as yet be said, though doubtless when the detailed information collected by the naturalists of the 'Challenger' is published we shall then derive much information on the subject. Some species have certainly a very wide range. This is the case, *e. g.*, with *Thalassicolla* and *Sphærozoum*, which have been found both in tropical and extratropical seas.

I should suspect that the exceptionally clear water of the Red Sea, devoid of impurity by reason of its riverless coasts, would be a very favourable station for these animals, unless the heat should be too great. But few forms have yet been seen in the North Sea, yet they exist in Baffin's Sea and Davis Straits.

As to the Mediterranean, Müller found Acanthometrine forms to predominate at Cette, and Polycystine forms at Nice, together with *Thalassicolla*. At St. Tropez he found all three. The distribution of the shells described by Ehrenberg is very extensive, reaching from the North Atlantic to the South-Polar Sea.

Their *geological* distribution is confined, for the most part, to the Tertiary rocks. If, however, *Traquairia* should be a Radiolarian, they would then extend back to the Carboniferous period. As to the intervening Secondary epoch, the flints of the Chalk are suspected to be partly formed by a redeposition of silica from their dissolved skeletons. Against this, however, Haeckel objects, because of their conspicuous absence amidst preserved Diatoms (so much smaller) and Polythalamian shells (so much more friable). Zittel, however, has shown that they exist in the Chalk, and there are imperfect remains even in the Trias.

Radiolarians, as is well known, largely contribute to form masses of Tertiary rock at Oran and in Barbadoes. They are also found fossil in Sicily, at Ægina in Greece, at Richmond and Petersburg in Virginia, at Piscatavey in Maryland, in Bermuda, between Chile and Bolivia, near Kasan, and in the Nicobar Islands. Only in the last-mentioned locality and in Barbadoes have they been found in large quantities and in many species (100 species in the former locality and 282 in the latter) forming great masses, which attain the height of 1100 feet in Barbadoes, and 2000 feet at Nicobar.

As far as yet known, the most ancient forms appear to be Polycystine Radiolarians—Cyrtidans, especially the *Zygocyrtida*,—as many as 229 kinds out of the 282 found in Barbadoes being Cyr-

tidans. It must be borne in mind, however, that the skeletons of such forms are amongst those most likely to be preserved.

Classification.

The best classification yet offered is that proposed by Haeckel, which is as follows*. He divides the whole group of Radiolarians into two sections:—A. MONOZOA or MONOCYTTARIA, the simple forms, and B. POLYZOA or POLYCYTTARIA, the compound forms.

His Monocyttaria are subdivided into two sections:—A, *a*. ECTOLITHIA, with the skeleton external to the capsule; and A, *b*. ENTOLITHIA, with more or less of the skeleton within the capsule. The Ectolithia are further subdivided into (1) the *Collida* (with a skeleton of scattered spicula or none), (2) *Acanthodesmida*†, (3) *Cyrtida*, (4) *Ethmosphærida*, and (5) *Aulosphærida*. His Entolithia he subdivides into (6) *Cœlodendrida*, (7) *Cladococcida*, (8) *Acanthometrida*, (9) *Diploconida*, (10) *Ommatida*, (11) *Spongurida* (with a skeleton wholly or in part spongy), (12) *Discida*, (13) *Lithelida*. His Polycyttaria he divides into (14) *Sphærozoida* (skeleton absent or in the form of scattered spicula), and (15) *Collosphærida* (skeleton a perforated shell, surrounding the capsule).

I think it would be very convenient, and therefore desirable, to endeavour if possible to unite together these fifteen different groups into large aggregations. Moreover, since Professor Haeckel's admirable monograph appeared, some new forms, the curious form *Myxobrachia* amongst others, have been discovered. Hertwig has also strongly insisted upon the greater importance of the nuclear vesicle (the *vesicula intima*) as a classificatory character than any characters which can be derived from the skeleton. The aggregation or non-aggregation of zooids into colonies seems to me a comparatively unimportant distinction, especially as individual zooids of the compound species are found (however derived) also in a single and separate condition. I cannot therefore but think the division of Radiolarians into two primary groups, the one single, the other compound, as an unnatural separation. As to the possession or non-possession of a nuclear vesicle (Binnenbläschen or *vesicula intima*), I quite agree with Hertwig that it would form a most important distinction; and I should propose to adopt it provisionally, fully bearing in mind that it may be found hereafter to be very widely, if not all but

* 'Radiolarien,' p. 237.

† The groups of which no characters are here given are characterized later, having been adopted by me from Prof. Haeckel.

universally, present in the group. Anyhow, I would make its presence or absence a primary character, and therefore follow Hertwig in separating off from Haeckel's *Collida* those forms which have the nuclear vesicle, and uniting them with the other genera which possess that structure into a group of VESICULATA. His remaining *Collida* (namely, *Thalassosphæra* and *Thalassoplaneta*) I would associate along with Haeckel's Polycyttaria into a group under the name COLLOZOA.

His *Acanthodesmida*, *Cyrtida*, and *Ethmosphærida* may then be, I venture to think, associated together as ectolithic, non-vesiculate, simple forms, the skeleton of which consists of more than detached spicula; and to this group the old name of POLYCYSTINA may well be applied.

A very important and natural character seems to me to be the possession of a large flagellum; and I would therefore propose to unite in a group of FLAGELLIFERA the genera *Spongocyclia**, *Spongodiscus*, and *Euchitonia*.

The meeting together of radii in the centre of the capsule seems to me a very special and peculiar condition; and I therefore regard as unnatural the separation from the thus characterized ACANTHOMETRIDA of forms (Haeckel's *Dorataspida*†) which differ only in having tangential outgrowths from their radii so disposed as by their mutual junction to form an external shell. I would therefore restore to the *Acanthometrida* those of Haeckel's *Ommatida* the radii of which thus centrally meet, as a separate subsection, to which I would restore the old name *Cataphracta*, to distinguish them from the more Acanthometrine forms, or *Typica*.

Again, *Diploconus*, as presenting the special character of centrally-joined radii, I would unite as a third section of the same great group, regarding its conical structure as a mere special modification of radial structure.

The remainder of Haeckel's *Ommatida* I would propose to unite with his *Cœlodendrida* and *Cladococcida*, as forms possessing an intracapsular more or less spheroidal shell. Moreover I cannot regard the possession of a spongy skeleton as a natural

* Though Haeckel failed to find this curious organ in two species of *Spongocyclia* (namely, in *S. cycloides* and *S. elliptica*), yet, as it is present in all the seven species of *Euchitonia*, I cannot but think its absence may have been due to some accident, or, at least, that such absence cannot be a character of those two species at all times. If, however, it should turn out to be constantly absent in them, then I think those two species should be eliminated from the group.

† *L. c.* p. 239.

character, existing, as it does, in such different forms as *Spongocyclia*, *Dictyoplegma*, and *Spongurus*. Therefore Haeckel's *Spongurida* seems to me an unnatural group. Accordingly I would remove from that assemblage *Dictyoplegma*, *Spongodictyum*, *Rhizosphæra*, and *Spongosphæra*; and associate them with the above *Ommatida* as ENTOSPHÆRIDA, dividing the group into four sections—(1) *Ommatida*, (2) *Spongosphærida*, (3) *Cladococcida*, and (4) *Cœlodendrida*.

At the same time I fully recognize that the mode of growth (by absorption and redeposition) of the last-named form is exceedingly noteworthy; and I should be inclined, on that account, to make a distinct primary group of it, but that I suspect an analogous mode of growth may exist, as yet undiscovered, in some other forms.

To Haeckel's *Spongodiscida* I would add the genus *Stylospongia*, as one of discoidal or cylindrical Radiolaria with spongy skeleton with or without radii; and I would unite these (as a subordinate group) with Haeckel's very natural section DISCIDA. As I have said, I cannot think the spongy nature of the skeleton to be an important character for the reasons already mentioned; while if such a form as *Spongodiscus* is to be associated with any other primary group, I think it must be with the *Discida*. I think so, because in them the skeleton is made up of a multitude both of circumferential and radial parts, and the skeleton of *Spongodiscus* is also made up of a multitude of circumferential and radial parts, only these are quite irregularly arranged instead of being regularly aggregated as in the typical *Discida*. To the *Discida* I would further add the genus *Lithelius*: not that I do not attach importance to the peculiarity of the structure of the latter; but I think that if we may add *Coccodiscus* (with its concentric spheroidal shells) to the *Discida*, on the one hand, we may also take into it *Lithelius* on the other.

In this way we shall succeed in reducing the primary groups from fifteen to seven, which may stand as follows:—

1. *Discida*; 2. *Flagellifera*; 3. *Entosphærida*; 4. *Acanthometrida*; 5. *Polycystina*; 6. *Collozoa*; and 7. *Vesiculata*.

Section I. DISCIDA.

Radiolaria mostly discoidal, sometimes elliptical, rarely cylindrical or spheroidal; skeleton in part intracapsular, and consisting always of both circumferential and radial parts, which may be

quite irregularly disposed, but which generally form an external perforated shell with an internal partition or spheroidal mass forming a series of mutually communicating chambers, which are either concentrically or spirally arranged: no flagellum; growth multipolar or centrifugal; no nuclear vesicle.

Subsection 1. Coccodiscida.

One or more concentric shells included within the internal shell. Genera: *Coccodiscus*, *Lithocyclia*, *Stylocyclia*, *Astromma*, *Hymeniastrum*.

Subsection 2. Trematodiscida.

Central chamber not different from the other and concentric chambers. Genera: *Trematodiscus*, *Perichlamydium*, *Stylodictya*, *Rhopalastrum*, *Stephanastrum*, *Histiastrum*.

Subsection 3. Discospirida.

Central chamber not different from the other and spirally arranged chambers. Genera: *Discospira*, *Stylospira*, *Stylospongia*.

Subsection 4. Lithelida.

Skeleton spheroidal, with the interior containing a mass of spirally arranged chambers. *Lithelius*.

Subsection 5. Spongida.

Skeleton with its chambers not separated off, the radial and circumferential elements being irregularly scattered, except that there are often radiating spines. Genera: *Spongodiscus*, *Spongotrochus*, *Spongurus*.

Section II. FLAGELLIFERA.

Radiolaria with a flagellum. No nuclear vesicle. Genera: *Spongocyclia*, *Spongoastericus*, *Euchitonia*.

Section III. ENTOSPHÆRIDA.

Radiolaria with an intracapsular spheroidal shell; not traversed by radii. No nuclear vesicle.

Subsection 1. Ommatida.

Two or three, or more, concentric spheroidal shells. No spongy skeleton.

Subdivision i. *Haliommatida.*

Two shells only. Genera: *Aspidomma, Haliomma, Tetrapyle, Heliodiscus, Ommatospyris, Ommatocampe.*

Subdivision ii. *Actinommatida.*

Three or more shells. Genera: *Actinomma, Didymocyrtis, Cromyomma, Chilomma.*

Subsection 2. SPONGOSPHÆRIDA.

One or more concentric shells, with spongy skeleton annexed.

Subdivision i. *Cladococcida.*

Shell with solid radiant spicula. Genera: *Rhaphidococcus, Cladococcus.*

Subdivision ii. *Cœlodendrida.*

Shell with hollow radiant spicula. Genus *Cœlodendrum.*

Section IV. ACANTHOMETRIDA.

Radiolaria with radial skeleton the radii of which meet in the centre of the capsule, and consisting more or less of acanthin. No nuclear vesicle; yellow cells generally absent.

Subsection 1. TYPICA,

Radii devoid of processes diverging from them at right angles, which by their union form a circumferential structure.

Subdivision i. *Acanthostaurida.*

Radii symmetrical, but only meeting at their apices within the capsule. Genera: *Acanthometra, Xiphacantha, Amphilonche, Acanthostaurus, Lithoptera.*

Subdivision ii. *Astrolithida.*

Radii symmetrical, but actually united at their apices. Genera: *Astrolithium, Staurolithium.*

Subdivision iii. *Litholophida.*

Radii unsymmetrical. Genera: *Litholophus, Actinellius.*

Subdivision iv. *Acanthochiasmida.*

Radii each perforating the capsule twice and adjoining, but not by their apices within the capsule. Genus *Acanthochiasma.*

Subsection 2. Diploconida.

Skeleton a double one, with radii also. Genus *Diploconus.*

Subsection 3. Cataphracta.

Acanthometrida with outgrowths at right angles from their radii forming a circumferential structure. Genera: *Dorataspis, Haliommatidium.*

Section V. POLYCYSTINA.

Simple, ectolithic Radiolarians with more or less compact skeletons, often with unipolar growth. No nuclear vesicle.

Subsection 1. Cyrtida.

Shell an external, more or less continuous, but perforated case variously formed, mostly with an open mouth at one pole; shell growing from one pole. No radial skeleton except external spines.

Subdivision i. *Monocyrtida.*

Shell single, without divisions. Genera: *Litharachnium, Cornutella, Cyrtocalpis, Pylosphæra, Spirillina, Haliphormis, Halicalyptra, Carpocanium.*

Subdivision ii. *Zygocyrtida.*

Shell divided by a vertical constriction. Genera: *Dictyospyris, Ceratospyris, Cladospyris, Petalospyris.*

Subdivision iii. *Dicyrtida.*

Shell divided by a transverse constriction. Genera: *Dictyocephalus, Lophophæna, Clathrocanium, Lamprodiscus, Lithopera, Lithomelissa, Arachnocorys, Dictyophimus, Eucecryphalus, Anthocyrtis, Lychnocanium.*

Subdivision iv. *Stichocyrtida.*

Shell divided by two or more transverse constrictions. Genera: *Eucyrtidium, Lithocampe, Thyrsocyrtis, Lithocorythium, Pterocanium, Dictyoceras, Lithornithium, Rhopalocanium, Pterocodon, Podocyrtis, Dictyopodium.*

Subdivision v. *Polycyrtida.*

Shell divided by several transverse or vertical constrictions. Genera: *Spyridobotrys, Botryocampe, Lithobotrys, Botryocyrtis.*

Subsection 2. Ethmosphærida.

One, or two or three circumferential shells united by radii; if one, then formed of a delicate network with irregular meshes. Genera: *Cyrtidosphæra, Ethmosphæra, Arachnosphæra.*

Subsection 3. Acanthodesmida.

Shell consisting of a few irregularly united bands. Genera: *Lithocircus, Zygostephanus, Acanthodesmia, Plagiacantha, Prismatium, Dictyocha.*

Section VI. COLLOZOA.

Simple or compound Radiolaria; if single, then with the skeleton in the form of circumferential detached spicula only. No nuclear vesicle.

Subsection 1. Polycollida.

Compound Radiolarians.

Subdivision i. *Sphærozoida.*

Skeleton absent, or consisting only of scattered spicula. Genera: *Collozoum, Sphærozoum, Rhaphidozoum.*

Subdivision ii. *Collosphærida.*

Skeleton a spheroidal perforated shell. Genera: *Siphonosphæra, Collosphæra.*

Section VII. VESICULATA.

Radiolaria with a nuclear vesicle.

Subsection 1. Collida.

Skeleton wanting, or consisting only of scattered circumferential spicula. Genera: *Thalassicolla, Thalassolampe, Aulacantha, Physematium.*

Subsection 2. Sphæroidea.

Vesiculata with one or more concentric extracapsular shells bound together by radii. Genera: *Heliosphæra, Diplosphæra*?

Subsection 3. Aulosphærida.

Vesiculata with a complex circumferential skeleton of hollow bars. Genus *Aulosphæra.*

Subsection 4. Brachiata.

Vesiculata with the extracapsular sarcode prolonged into one or more arm-like processes. Genus *Myxobrachia.*

The Relations of the Radiolaria *to other Organisms.*

That the Radiolaria form a very well-defined and distinct group of Protozoa is admitted on all hands; but the question at present disputed is whether or not the resemblance between them and the Heliozoa is such as to make it desirable to unite them as two subdivisions of one larger group, itself distinct from all the other larger groups of Protozoa. In his latest paper on the histology of the Radiolaria, Hertwig leaves the question undecided whether it is the more natural arrangement to make, on the one hand, the Heliozoa, Radiolaria, and Thalamophora three distinct and co-equal equivalent groups, or, on the other hand, to form two great groups—the one containing the Heliozoa and Radiolaria, the other containing the marine and freshwater Thalamophora.

On the whole, I am at present inclined to regard the Radiolaria as an altogether distinct group, and not to unite it with the Heliozoa; and at the same time it seems to me to be unquestionable that of all the above Protozoa, the Heliozoa are those which come nearest to the Radiolaria.

In an earlier paper* he denied that any near relationship existed between the Heliozoa and Radiolaria. He made this denial on the ground of the supposed cellular nature both of the external and internal alveoli, and also of the "*wasserhellen Bläschen*" as well as on other accounts. As he has now, however, become convinced that alveoli are but vacuoles without membranous walls, and that the "*wasserhellen Bläschen*" are but nuclei, these two reasons fall to the ground. The following distinctions, however, seem still to remain intact:—

(1) A porous capsular membrane present in the *Radiolaria*, absent in the *Heliozoa*.

(2) A gelatinous investment present in the *Radiolaria*, absent in the *Heliozoa*.

(3) Reproduction in the *Radiolaria* by means of numerous zoospores †, each with a nucleus and flagellum, but with

* See Hertwig and Lesser, "Ueber Rhizopoden und denselben nahestehende Organismen," Archiv für mikrosk. Anat. vol. x. Suppl.-Heft, p. 147.

† Such parts have not yet been found in any other Rhizopods, least of all in the Heliozoa, in which a single procees of division gives rise to a small number of individuals. The zoospores of Radiolaria are most nearly resembled by those of *Myxomycetes*; but there the reproductive process is very different.

no vacuoles. In the *Heliozoa*, on the other hand, the much fewer separated reproductive parts have each two flagella (as in most Rhizopods), several contractile vacuoles, and a nucleus with vacuoles and nucleoli.

(4) Yellow cells present in almost all *Radiolaria*, absent in *Heliozoa*.

(5) The *Radiolaria* are entirely marine, while the yet known *Heliozoa* are almost entirely freshwater.

(6) The pseudopodia of Radiolarians have no axis-fibre similar to that so often found in the *Heliozoa*.

The similarity between these two groups in external form and chemical composition is undeniable; but, as Hertwig points out, very many of the Radiolaria depart widely from the spherical form, while the similarity of chemical composition cannot be considered as a distinction of great weight, seeing that the similarity is shared with many other lowly organisms of quite different affinities. The distinction as to the medium inhabited is also much weakened by the discovery of the salt-water Heliozoa, *Pinacocystis rubicunda* and *Actinolophus pedunculatus*.

Again, though the differences which exist between the reproductive processes (above enumerated as No. 3) are very great, yet we must recollect that there are also great differences in this respect between different Heliozoa, while the reproductive processes of so few Radiolarians have yet been examined, that it would be rash to feel confident that no important divergencies will be hereafter found to exist amongst them in this respect.

With respect to the capsule itself (which seems to form so very marked a difference) the distinction would be weakened if it should turn out that young Radiolarians which have not yet acquired a capsule, nevertheless show a differentiation of their sarcode into an inner and an outer layer, like the medullary and cortical parts of Heliozoa; and this may be indicated by Cienkowski*. The distinction would not only be weakened, but would break down if it should be shown that certain adult Radio-

* See Archiv für mikrosk. Anat. vol. vii. p. 374, and pl. xxix. fig. 1. He says as to the young condition without a capsule, "Die jungen Kapseln sind nackt ohne Schale in eine strahlende Protoplasmaschicht eingebettet, von keiner scharf conturirten Hülle umgrenzt. In diesem Stadium theilen sie sich häufig durch Abschnürung in zwei Hälften."

larians have no capsule at all, a condition which seems indicated by Sir C. Wyville Thomson *.

In spite, however, of these latter considerations, I am inclined, on the strength of the distinctions above enumerated, to keep provisionally apart, as two equivalent and divergent groups, the Heliozoa and the Radiolaria.

As to the unicellular nature of Radiolarians, the most recent researches of Hertwig have convinced him that however diverse may be the contents of the capsule, they are nevertheless only the products of the differentiation of a single cell, such as we find in many small animals and in plants, which are admitted to be unicellular.

The yellow cells, however, stand markedly apart; and if Hertwig is right in his views respecting them, then those true cells must take their rise in a multinucleate sarcode as a true endogenous cell-formation—a rare occurrence.

If, however, the yellow cells should turn out to be parasitic organisms, they will not only thus cease to be mysterious, but the circumstances will render the truly cellular nature of the "centripetal cell-groups" of *Physematium* more improbable, seeing that they will then be the only instance of true cells in the Radiolaria, and thus the existence of some error of observation in this regard will seem more probable.

If Hertwig is right in his view as to the origin of the nuclei of *Thalassicolla*, then we have therein a mode of origin elsewhere unknown amongst animals, viz. nucleoli dividing, passing out from the nucleus, and becoming nuclei themselves. The author's previous observations † as to nuclei would appear to make his theory less improbable; but it should be duly noted that Professor W. Flemming disputes ‡ Hertwig's views.

Without venturing to express an opinion in this controversy, I would place on record that Hertwig has come to the conclusion that a multinucleolate cell is potentially multinucleate, as a multinucleate cell is potentially multicellular; and thus we get a

* His words are:—"In many Radiolarians, and especially in some very peculiar compound forms, a spherical internal chamber, called the 'central capsule,' whose function we do not fully understand, is very prominent. This capsule is, however, absent, or at all events exists in a very modified form, in the more typical groups."—'Voyage of the Challenger,' vol. i. p. 232.

† 'Morphol. Jahrbuch,' vol. ii. p. 63, pl. iii.

‡ Archiv f. mikrosk. Anat. vol. xiii. 1877, p. 692, pl. xlii.

transition from unicellular to multicellular organisms. Hertwig's view does, in fact, seem to be, as he says it is, the old view, that the nucleolus divides first, and then the nucleus. In support he refers to the labours of Carter, Wallich, Greef, Claparède, and Lachmann, as showing that in the nucleus of Rhizopods numerous nucleoli develop themselves, which pass out from the nucleus and grow in the surrounding protoplasm into Amœbiform bodies with a nucleus and contractile vacuoles. He also refers to Auerbach's multinucleolate nuclei in the tissues of Dipterous larvæ about to assume the pupa condition.

To conclude, the multicellular nature of Radiolarians now depends entirely on the normal nature of their yellow cells, and on the correctness of the observations as to the centripetal cell-groups of *Physematium*.

As has been said, neither of these phenomena can be reposed on as being certainly of the nature of true cells forming part of the normal organization of the Radiolarians in which they have been found; but even if they are so, and if we are compelled therefore to regard Radiolarians as multicellular, their multicellularity is of a radically different kind from that of any of the Metazoa, and none of their parts, whether truly cells or not, have any valid claim to the denomination of a tissue.

Literature.

In the great work of Professor Haeckel, 'Die Radiolarien,' will be found complete and ample references to all the literature of the Radiolaria antecedent to its publication. Since its appearance the following publications, relating to these animals, have appeared.

Ehrenberg. Abhandlungen der könig. Akad. der Berlin, 1862, pp. 39–74, pls. i.–iii.; 1868, pp. 1–55; 1869, pp. 1–66, pls. i.–iii.; 1870, pp. 1–74, pls. i.–iii.; 1871, pp. 1–150, pls. i. & ii.; 1872, pp. 131–400, pls. i.–xii.; 1875, pp. 1–225, pls. i.–xxx.

(These papers contain notices, with or without figures, on different Radiolarians, with observations on their distribution in time and space.)

Ernst Haeckel. Zeitschrift für wissenschaft. Zoologie, vol. xv. p. 342, pl. xxvi., 1865.

(A memoir on the sarcode of Rhizopods, with special references to many Radiolaria, and with descriptions and figures of the new

genus *Actinelius* and the new species *Acanthodesmia polybrocha* and *Cyrtidosphæra echinoides.*)

A. Schneider. Archiv für Anatomie und Physiologie, p. 509, 1867.

(An histological investigation, showing the comparative unimportance of the extracapsular portion of the sarcode, at least in *Thalassicolla.*)

James Dana. Amer. Journ. of Science and Arts, May 1863, and Ann. & Mag. Nat. Hist. 3rd ser. vol. xii. p. 54, 1863.

(A very short notice of *Sphærozoum*, suggesting a relation between it and sponges.)

Wallich, Dr. G. C. 'North-Atlantic Sea-bed.' Van Voorst, 1862.

(Unfinished; plates named, but figures unfortunately without descriptions.)

Wallich, Dr. G. C. On the Structure and Affinities of the *Polycystina.* Quarterly Journal of Microsc. Science, vol. v. (n. s.) 1865, pp. 75–84.

Wallich, Dr. G. C. Ann. & Mag. Nat. Hist. 4th ser. vol. iii. p. 97, 1869.

(Observations on *Thalassicolla* and *Sphærozoum*; no mention is here made of Haeckel's monograph.)

Ernst Haeckel. Jenaische Zeitschrift, vol. v. p. 519, pl. xviii. Republished in 'Biologischen Studien,' pt. 1. See also Quarterly Journal of Microscopical Science, (n. s.) vol. xi. p. 63, pl. v.

(Description, with figures, of the curious form *Myxobrachia*, here first made known.)

Alex. Stuart. Neapolitanische Studien. Göttingen Nachr. 1870, No. 6.

(A work of little value, in which the well-known Foraminifer *Globigerina echinoides* is described as a Radiolarian under the name *Coscinosphæra ciliosa.*)

N. Wagner. Bulletin de l'Acad. de St. Pétersbourg, vol. xvii. p. 140.

(Herein is noticed a new species of *Myxobrachia, M. Cienkowskii.*)

Macdonald, Dr. J. D. Quarterly Journ. of Microscopical Science, (n. s.) vol. ix. p. 147, pl. xi., 1869.

(In which is briefly treated points concerning *Sphærozoum*, *Collosphæra*, and *Thalassicolla nucleata.*)

MACDONALD, Dr. J. D. Ann. & Mag. Nat. Hist. 4th ser. vol. viii. p. 224, 1871.

(A short paper, containing a notice of *Acanthometra* and *Dictyocha*, with a woodcut of *Astromma Yelvertoni*, and observations on modes of growth.)

L. CIENKOWSKI. Archiv f. mikrosk. Anat. vol. vii. p. 371, pl. xxix., 1871.

(A valuable paper, wherein is first accurately described the formation of zoospores, with observations on the reproduction of *Collosphæra* and *Collozoum*, and notes upon yellow cells. This paper has been translated in the 'Quarterly Journal of Microscopical Science, (n. s.) vol. xi. p. 396, pl. xviii.)

W. DONITZ. Arch. f. Anat. und Phys. p. 71, plate ii., 1871.

(Observations on Radiolaria, in which he treats of *Thalassicolla*, *Collozoum*, and *Sphærozoum*, describing a new species (*S. Sanderi*) of the last-named genus. He appears, though, to have confounded the earlier with the later stages of *Collozoum*, and fallen into other errors of interpretation: see Hertwig, Zur Hist. d. Rad. pp. 9, 10.)

HERTWIG and LESSER. Archiv f. mikrosk. Anat. vol. x. Suppl. p. 147, 1874.

(In this treatise the question of the relationship of the Radiolaria to the Heliozoa is considered; and they are said to have no near relationship.)

FOCKE, G. W. Zeitschrift für wissen. Zoologie, 1868, vol. xviii. p. 345. Translated in 'Quarterly Journal of Microscopical Science,' vol. ix. 1869, pp. 67–75.

(The author considers some Heliozoa discovered by him as true freshwater Radiolaria; but they do not present true Radiolarian characters.)

W. ARCHER. Quarterly Journal Microsc. Science, (New Ser.) vol. ix. p. 250, 1869.

(Freshwater Heliozoa described, with a reference to Focke's paper, asserting the existence of pulsating vacuoles.)

GREEF. Archiv für mikrosk. Anat. vol. v. p. 464, and vol. xi. p. 1, pls. i. & ii.

(In the former paper the author describes Heliozoa, and is inclined to regard the inner body of *Clathrulina* as representing the Binnenblase of the Radiolaria. In the latter place he reconsiders the homology asserted by some (*e. g.* A. Schneider) to exist

between Radiolarian yellow cells and the green cells of the Heliozoon *Acanthocyrtis*, deciding that the question cannot be settled till the genesis of both cells is understood; but that if they *are* homologues, then the outer wall of *Acanthocyrtis* cannot be the homologue of a central capsule.)

Also Sitzungsb. d. niederrheinischen Gesellsch. Jan. 1871.

And Sitzungsb. d. Gesellschaft f. Natur. zu Marburg, No. 5, 1875.

Carruthers, W. British Assoc. Reports, 1872, p. 126, and Quart. Journ. Microsc. Science, (n. s.) vol. xii. p. 397, 1872.

(On *Traquairia*, a Radiolarian Rhizopod from the Coal-measures.)

Grenacher. Zeitschr. f. wissen. Zoologie, vol. xix. p. 289.

(The author, *à propos* of *Acanthocyrtis viridis*, expresses his opinion that the Heliozoa are a less differentiated branch from a root-stem, from which the Radiolaria are a more differentiated branch, bearing to the latter a relation similar to that borne by the freshwater Hydra to the marine Hydroid polyps.)

Hertwig, Dr. R. Morphol. Jahrbuch, vol. ii. p. 63, pl. iii.

(In this the author puts forward his views as to the formation of nuclei from so-called nucleoli.)

Hertwig, Dr. R. Zur Histologie der Radiolarien. Leipzig, 1876.

(A most excellent treatise on the structure and reproduction of *Collozoum inerme*, *Thalassicolla nucleata*, and *Thalassolampe margarodes*, with considerations on the relations borne by the Radiolaria to the other Rhizopods, and the bearing of the facts noted on the cell-theory.)

Zittel, Karl A. Handbuch der Paläontologie, I. Band, p. 117, 1876.

(The author notices the fossil Radiolaria of the Mesozoic strata.)

Zittel, Karl A. Ueber fossile Radiolarien der ob. Kreide. Zeitschrift d. deutschen geol. Ges. (1876), Band xxviii. Heft 1.

Flemming, Prof. Walther. Archiv f. mikrosk. Anat. vol. xiii. p. 629, pl. xlii., 1877.

(An elaborate paper, wherein the author takes occasion to criticise and oppose Dr. Hertwig's views as to the nucleus and nucleolus, their multiplication and reproduction.)

On the Minute Structure of *Stromatopora* and its Allies. By Prof. H. Alleyne Nicholson, F.L.S. &c., and Dr. J. Murie, F.L.S. &c.

[Read December 20, 1877.]

(Plates I.–IV.)

Introductory Remarks.

The last decade, or thereabouts, has indeed witnessed vast changes in the opinions held as to the position and relationship &c. of several groups and so-called aberrant genera and species among the Invertebrates. This, to a great extent, has been brought about by the very considerable improvements in the modes of manipulation, investigation, and treatment of minute structure &c., and doubtless to the coordinate impetus given to the study of certain hitherto obscure forms, both as to their development and subsequent life-history.

The forms or groups of forms which constitute the basis of the present investigation have been regarded within the last fifty years in the most diverse aspects. *Stromatopora*, even at the present moment, occupies a most unsettled and uncertain position, while hints and doubts flow freely as to whether it be allied to the Calcareous or the Siliceous Sponges, to the Foraminifera, to the Corals, to the Hydrozoa, or to the Polyzoa, or whether it may not be a heterogeneous assemblage of dissimilar forms, or perhaps the representative of a special and now extinct group of organisms. Unfortunately the animal itself cannot be appealed to as affording evidence towards the solution of this problem, the remains of its habitation, or its skeletal structures, alone offering data upon which any judgment on this disputed point may be arrived at. The object, then, of this communication is to present the results of a careful examination of a large number of specimens and sections of different forms of *Stromatopora* and of related groups. These results, it is hoped, will serve to throw some light upon the anatomy and systematic position of the Stromatoporoids—though, as a matter of course, some points have necessarily been left doubtful or unsettled, to a large extent owing to the impossibility of obtaining access to many of the original specimens described by earlier observers.

In carrying out this investigation the materials at our disposal have consisted of a very extensive suite of specimens in various

states of fossilization, from the Lower and Upper Silurian and the Devonian rocks of Canada and the United States, specimens from the Upper Silurian and Devonian of Britain, and a few from the Upper Silurian deposits of Sweden. The great majority of these specimens have been personally collected by us, so that we are able to speak with precision as to the exact *gisement* of the specimens, and as to the condition of fossilization of the organic remains associated with them. A large number of the microscopic sections have also been personally prepared by us, and we are thus enabled to indicate with certainty their precise relations to the specimens from which they are taken*.

History and Literature.

As regards the history of the genus, the following are the principal works with which we are acquainted, or to which we have been able to obtain access during the course of our investigations, excluding memoirs wholly concerned with descriptions of species.

The genus *Stromatopora* was originally founded by Goldfuss ('Petrefacta Germaniæ,' 1826), and it was based upon the form which has been generally known as *Stromatopora concentrica*. At a subsequent page of the same work he describes another form under the name of *S. polymorpha*, and defines the genus, referring it to the Sponges. It is, however, now certain, as Roemer has shown by an examination of the original specimens of Goldfuss ('Lethæa Palæozoica,' 1877, explanation to pl. xxvi.), that these two species are identical; and though the latter form is described

* As this is a joint communication, it may be well to define to some extent how far each of the authors is responsible for particular parts of the work. One of the present writers (H. A. N.) had already devoted considerable attention to the Stromatoporoids, having published several memoirs on the group, and having arrived at tolerably definite views as to their structure and affinities, though these views were not based upon the examination of thin sections with the microscope. The great bulk of the material has also been collected and worked out by the writer just alluded to. On the other hand, his colleague brought to bear upon the subject a mind free from all preconceptions and prepossessions; and the entire question of the structure and affinities of this most difficult group of fossils has thus been most carefully debated and discussed between the two writers. This has involved extensive research on a number of collateral points, wherein each has furnished his quota. Nor need we shrink from stating that as fact after fact was accumulated, each has been obliged to shift his ground more than once before arriving at a final decision, the difficulties, as is so often the case, presenting themselves concomitantly with the increase of our knowledge.

most fully and from the best-preserved specimens, it must be abandoned in favour of the previously described *S. concentrica.* Still it follows from this that the type of the genus *Stromatopora* is not the entirely vague and undeterminable form which palæontologists have been in the habit of calling *S. concentrica*, but the well-marked and sharply characterized *S. polymorpha.*

De Blainville ('Manuel d'Actinologie,' 1834) refers *Stromatopora*, with doubt, to the Corals.

Steininger (Mém. de la Soc. Géol. de France, t. i., 1834) describes several species of *Stromatopora* from the Eifel limestone, and refers the genus to the Sponges.

Lonsdale (Trans. Geol. Soc. Lond. ser. 2, vol. v., 1840) places *Stromatopora* among the Corals; and he describes and figures a Stromatoporoid fossil under the name of *Coscinopora placenta.*

Professor Phillips ('Palæozoic Fossils of Cornwall,' &c., 1841) describes and figures some Stromatoporoids from the Devonian of Devonshire. He also founds the genus *Caunopora* for Lonsdale's *Coscinopora placenta*, and describes a new form of the same under the name of *C. ramosa.* As so many subsequent observers have done, Phillips regards the "radial" elements of the skeleton of *Stromatopora* as being *tubes*, a belief which is unequivocally disproved by microscopic examination, as first satisfactorily shown by Von Rosen.

In 1843, Ad. Roemer ('Die Versteinerungen des Harzgebirges') described some Stromatoporoids, placing one among the Sponges, and the rest among the Corals. In the same year Keyserling ('Reise in das Petschora-Land') expressed the opinion that the genus *Stromatopora* should be placed among the Corals, and that it is nearly allied to *Alveolites*, Lam.

In 1844, Ferdinand Roemer ('Das rheinische Uebergangsgebirge') published the opinion that *Coscinopora placenta*, Lonsd. (=*Caunopora placenta*, Phill.), is founded upon specimens of *Stromatopora* attached parasitically to a coral.

In 1844, Prof. M'Coy ('Synopsis Carb. Limestone Foss. of Ireland') described briefly some more or less obscure fossils from the Carboniferous Limestone of Ireland, to which he gives the names of *Caunopora placenta*, Phill., *Stromatopora concentrica*, Lonsd., *S. polymorpha*, Gold., and *S. subtilis*, M'Coy. The true structure and nature of these must remain at present doubtful.

In 1847, Hall ('Pal. New York,' vol. i. p. 48, pl. xii.) founded the genus *Stromatocerium* for a Stromatoporoid from the Trenton

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Limestone of North America, the structural characters of the genus, however, being left undefined. In the same work (vol. ii. p. 135, 1852) Prof. Hall states that, according to his observations, the skeleton of *Stromatopora* is "composed of minute cylindrical tubes with considerable space between, and that the laminated structure arises from thin layers of calcareous matter deposited and filling the spaces between and filling the tubes." He considers the genus to be referable to the Corals, and to be "more nearly related to *Tubipora* than to any other genus."

In the 'Prodrome de Paléontologie' (1850), D'Orbigny places the genus *Stromatopora* among the Sponges, and gives short definitions of some species, founded, of course, upon macroscopic characters only. In the 'Cours Élémentaire de Paléontologie' (1851), the same observer again places the genus in the same systematic position. D'Orbigny's genus *Sparsispongia*, however, would seem to be founded upon Stromatoporoids of the type of, or identical with, *Stromatopora polymorpha*, Goldf.

In 1851, Prof. M'Coy ('Brit. Pal. Foss.' p. 12) expressed the opinion that *Stromatopora* is a true Coral, allied to *Fistulipora* and *Palæopora* (=*Heliolites*). His definition of the genus is:—"Corallum calcareous, forming large amorphous masses composed of very thin superposed layers of minute vesicular tissue of the thickness of one cell each, occasionally marked on the upper surface with extremely obscure, distant, quincuncially-arranged small pits."

The two Sandbergers ('Die Versteinerungen des rheinischen Schichtensystems in Nassau,' 1850–56, p. 380) consider that *Stromatopora* properly belongs to the Polyzoa; but they base this view upon the unquestionably erroneous interpretation of the "radial pillars" as being *tubes*.

The same view as to the affinities of *Stromatopora* is expressed by Professor Ferdinand Roemer ('Lethæa Geognostica,' 3rd ed. vol. i. p. 166), who compares the genus with the recent *Cellepora*; and who explains the apparent absence of "cells" upon the ground that perhaps these structures were extremely minute, or the cell-walls were very destructible. Roemer adds, however, that since he expressed this opinion, he has examined specimens of *S. polymorpha* from the Eifel, in which he can detect both prismatic tubes and tabulæ, and that the genus will therefore probably have to be removed to the "Tabulate Corals" and placed near *Chætetes* and *Favosites*.

Eichwald, on the other hand ('Lethæa Rossica,' vol. i. p. 345, 1860) defines *Stromatopora* as composed of a spongy mass constructed of closely approximated lamellæ and enveloping other organic bodies, its surface covered with minute rounded pores arranged without order over the whole surface of the skeleton, the latter being formed of a network of very minute horny fibres. M. Eichwald is thus the first, so far as we are aware, to promulgate the view, afterwards so strongly supported by Von Rosen, that the Stromatoporoids were really composed of horny fibres in their original constitution.

In 1866, Prof. Winchell ('Report on the Michigan Peninsula') described several species of *Stromatopora*; but we have unfortunately been unable to obtain access to this work for consultation.

In the 'Proceedings of the American Association' for 1866 the same author also defines the genus *Cœnostroma*, and discusses the affinities of the Stromatoporoids in general; but this memoir also we have unluckily been unable to consult.

The most important contribution to the structure and history of the Stromatoporoids is that published in 1867 by Von Rosen, under the title 'Ueber die Natur der Stromatoporen, und über die Erhaltung der Hornfaser der Spongien im fossilen Zustande.' In this work the author considers the structure of *Stromatopora* as elucidated by means of vertical and horizontal (or, better, "tangential") sections prepared for microscopic examination, and the highest praise must be accorded to his plates for their accuracy and fidelity to nature. We are not, however, able to agree with the main thesis of his valuable memoir, which he supports by evidence drawn both from the study of *Stromatopora* itself and from collateral sources, namely, that the skeleton of the Stromatoporoids was originally composed of minute horny fibres, which were replaced, in the process of fossilization, by carbonate of lime. We quite coincide, on the other hand, with the author's view, that the belief that the ordinary and typical Stromatoporoids were originally *siliceous* is not supported by the evidence at present in our hands.

In 1870, Dr. Gustav Lindström published an important paper on the Anthozoa Perforata of Gotland ('Kongl. Svenska Vetenskaps-Akad. Handlingar,' Bd. ix.), in which he describes and figures the *Porites discoidea* of Lonsdale as a Stomatoporoid under the name of *Cœnostroma discoideum*. He regards *Cœnostroma* as

a true coral closely allied to the existing Poritidæ; and he justly points to the close resemblance in appearance and general structure between *Cœnostroma* and *Psammocora*. While admitting this resemblance, the passage between *Cœnostroma* and *Stromatopora* proper is easily effected by means of forms like *Syringostroma*; and the minute structure of the former forbids our acceptance of the view that it can really be a coral. *Stromatopora* itself is regarded by Lindström as probably Foraminiferal.

In a paper on the affinities of the Anthozoa Tabulata (Œfversigt af Kongl. Vetenskaps-Akad. Förhandl. 1873, translated in Ann. & Mag. Nat. Hist. 1876), Dr. Lindström indicates that *Cœnostroma*, Winchell, which is an undoubted Stromatoporoid, presents certain affinities to *Labechia*, E. & H.; and he regards this latter genus as Hydrozoal, and as related to the recent *Hydractinia*. On this point, however, we shall have more to say hereafter.

In the 'Twenty-third Annual Report on the State Cabinet,' dated 1873, but, we believe, not actually published till 1874, Prof. Hall describes several species of *Stromatopora* from the Devonian rocks of the United States. In describing a species of *Caunopora*, Phill., he expresses some doubt as to the propriety of separating *Caunopora* and *Cœnostroma* from *Stromatopora* proper, upon the ground that both, when carefully examined, "prove to be made up of a series of vertical columns" (our "radial pillars") "connected by lateral filaments, which radiate more or less regularly at given intervals, and unite the several columns to each other, just as in the typical *Stromatopora*; and it is these lateral processes which in a vertical section give the appearance of horizontal plates."

In 1873, Salter expressed the opinion that *Stromatopora* is "a very solid calcareous sponge" ('Cat. Sil. Foss.' p. 99).

In 1873 (Ann. & Mag. Nat. Hist. ser. 4, vol. xii.) one of the present writers described several species of *Stromatopora* from the Upper Silurian and Devonian strata of Canada, indicating in one of them (*S. ostiolata*, Nich.) the presence of large apertures believed to correspond to the "oscula" of sponges.

In 1874, the same writer (Ann. & Mag. Nat. Hist. ser. 4, vol. xiii.) discussed the affinities of the genus *Stromatopora* upon general grounds, referring it to the Calcispongiæ, and indicating the presence in examples of various species of large "oscular" openings. The skeleton was regarded as "composed of an amalgamated system of horizontal spicules separated by interspaces and kept

apart by a vertical system of delicate calcareous rods, giving rise to a system of more or less quadrangular tubes." In the 'Report on the Palæontology of the Province of Ontario' (1874), the same opinion is repeated; and in the 'Palæontology of the State of Ohio' (vol. ii., 1875), the author describes several additional species of *Stromatopora*, and founds the genera *Syringostroma* and *Dictyostroma*.

In the 'Dawn of Life' (1875), Principal Dawson incidentally gives the result of his observations on the structure of *Stromatopora* and its allies, apparently regarding them as intermediate between the Foraminifera and the Sponges. This distinguished palæontologist further describes in *Caunopora* and *Cœnostroma* a system of tubes or groups of tubes which traverse the horizontal laminæ of the skeleton, and "in each successive floor give out radiating and branching canals exactly like those of *Eozoön*." From Dr. Dawson's description and figures, we should be disposed to imagine that in this statement he is referring to the comparatively large radiating and vertical canals which are present in most, if not in all, of the Stromatoporoids, and which are, as a rule, visible even to the naked eye. If, however, he is referring to any microscopic tubules at all comparable to the minute "tubuli" of the test of the perforate Foraminifera, then we can only say that though we have in some thin sections imagined that we had met with indications of such a tubulation of the skeleton, we have hitherto failed, after the most careful investigation, to satisfy ourselves as to the real existence of such a structure.

In a memoir upon *Stauronema*, a new genus of fossil Hexactinellid Sponges (Ann. & Mag. Nat. Hist. ser. 4, vol. xix.), Mr. Sollas places *Stromatopora concentrica* (under the new generic title of *Callodictyon*) among the Vitreo-hexactinellid sponges, in the family Aphrocallistidæ. In a subsequent paper ("The Structure and Affinities of the Genus *Siphonia*," Quart. Journ. Geol. Soc. 1877), the author says that he does not regard the genus *Stromatopora* as wholly referable to the Vitreo-hexactinellidæ, but that part is Hydrozoal and related to *Millepora* and *Hydractinia*, and that part belongs to other groups not yet determined.

Mr. Carter (Ann. & Mag. Nat. Hist. ser. 4, vol. xix. 1877) has expressed the opinion that *Stromatopora* and allies are closely related to the living genus *Hydractinia*, and that the extinct genus *Parkeria*, described by Dr. W. B. Carpenter as a Forami-

nifer, is also truly Hydrozoal and related to *Hydractinia*. Upon this point we must speak with considerable diffidence, as not having seen and examined the specimens upon which Mr. Carter's views are based. We have, however, examined a large series of specimens and sections of *Parkeria*, including typical examples kindly furnished us by Dr. Carpenter himself; and we believe the view that it is an Arenaceous Foraminifer to be the one most in accordance with the facts exhibited by these specimens. We quite admit the likeness in structure presented by some forms of *Stromatopora* to *Parkeria*; but having arrived at the conclusion that all the Stromatoporoids were primitively calcareous, we are unable to admit that there is any real affinity between these two groups of organisms. As regards the ordinary forms of *Hydractinia*, we can fully recognize the resemblance which these present to the Silurian fossils described by Milne-Edwards and Haime under the name of *Labechia*, a resemblance which, as we have already indicated, was long ago pointed out by Lindström, though even in this case the apparently solid pillars of *Labechia* can hardly be paralleled with any structure present in *Hydractinia*. We are not, however, so far as the extensive series of specimens which we have examined will allow us to judge, prepared to admit that any relationship of real affinity subsists between *Stromatopora* and *Hydractinia*, though the existence of calcareous species of the latter genus is certainly a noteworthy fact. As to the existence, lastly, of siliceous species of *Hydractinia*, such as described by Mr. Carter from the Upper Greensand of Haldon Hill, we think that it would be desirable to obtain more evidence than has yet been published, proving that such apparently siliceous forms are not merely *silicified* examples of originally calcareous specimens. We do not of course assert that this is the case; but we think that this is a consideration which cannot be overlooked in any discussion of this question.

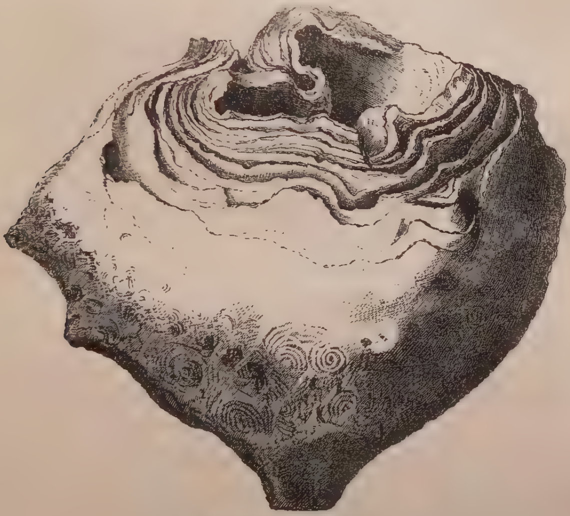
Lastly, Professor Zittel, in a supplementary note to the English translation (Ann. & Mag. Nat. Hist. ser. 4, vol. xix. 1877) of his masterly memoir entitled "Beiträge zur Systematik der fossilen Spongien" ('Neues Jahrbuch für Mineralogie,' &c. 1877), gives his adhesion to Mr. Carter's view that the Stromatoporoids are really to be regarded as allies of *Hydractinia*, and as belonging, therefore, to the Hydrozoa*.

* Since the above was written, the following additional papers upon the Stromatoporoids have been published or read:—

General Structure of a Typical Stromatopora.

If we take a typical species of *Stromatopora*, such as *S. concentrica*, Gold., of the Devonian, we find that it presents itself

Fig. 1.



Stromatopora rugosa.

A small and perfect specimen, of the natural size, from the Trenton Limestone of Canada. (After Billings.)

Dr. Steinmann has published a memoir, "Ueber fossile Hydrozoen" [Palæontographica, n. F. v. 3 (xxv.), p. 101], in which he refers *Stromatopora* to the Hydractiniidæ, and as being structurely similar to his new genus *Sphæractinia*.

Mr. Carter expresses the opinion that *Stromatopora* is identical in structure with the recent *Millepora alcicornis* (Ann. & Mag. Nat. Hist. ser. 5, vol. i. p. 298). A perusal of Mr. Carter's remarks will at once show that in speaking of "*Stromatopora*" he is really alluding only to the curious and aberrant *Caunopora*. In a second paper (ibid. p. 412) Mr. Carter announces that he has detected "hexactinellid structure" in *Stromatopora* from Devonshire, and in a third (ibid. vol. ii. p. 85) he says that the form presenting this structure is *S. concentrica*, and that he has determined this to be really *Caunopora*, Phill.

In a paper on the Microscopic Structure of the Stromatoporidæ, not yet published in full, Principal Dawson gives grounds for believing that the Stromatoporoids are truly Foraminiferal, and are the Palæozoic representatives of *Eozoön* (Abstract, Proc. Geol. Soc. No. 355, p. 4).

Finally, Mr. A. Champernowne (ibid. p. 5) gives an account of the Stromatoporoids of Devonshire, and his views as to their structure and nature.

in the form of rounded subhemispherical or irregularly spheroidal masses, or of flattened expansions of an incrusting character, composed of thin, close-set laminæ arranged concentrically round one or more centres. These concentric and fundamentally horizontal laminæ are separated by interspaces, which are crossed by more or less numerous vertical pillars, or, as we shall term them, "radial pillars." Hence the vertical section exhibits a number of approximately horizontal layers and intervening spaces, the latter divided by upright pillars into a number of minute vesicular compartments. In some instances the entire laminated mass has grown, as has often been described, in successive superimposed layers round some central nucleus, such as the shell of a mollusk or a coral; but this is by no means universally the case. On the contrary, many examples were attached by a narrow base to some foreign body (such as a coral), developing upwards into a more or less extended expansion, the under surface of which is covered by a wrinkled and imperforate epithecal membrane.

Mode of Occurrence, Condition of Fossilization, and Original Constitution.

Stromatopora and its allies are found in detached masses or expansions, often of very considerable dimensions, and frequently in very great numbers in particular localities. They occur most commonly in limestones, associated with Corals, Brachiopods, and other marine fossils; but they also occur in argillaceous sediments. As to the condition of fossilization in which they occur, some specimens are calcareous, others are siliceous, others are partially calcareous and partially siliceous.

As to the *original constitution* of the hard structures of the Stromatoporoids, it has generally been assumed that the skeleton was calcareous. There are, however, four views which may be entertained on the subject:—

First. It may be held that *Stromatopora* was originally *calcareous*, and that all specimens which we now find in a more or less completely siliceous condition owe this to their having been more or less thoroughly subjected to the familiar process of "silicification."

Secondly. It may be held that *Stromatopora* was primitively *siliceous*, and that all calcareous specimens owe their present constitution to the fact that the original silica of the specimen has been replaced by carbonate of lime. Mr. Sollas (Ann. & Mag. Nat. Hist.

ser. 4, vol. xix.) would seem to be in favour of this view, at any rate in part.

Thirdly. As has been suggested to us by Dr. W. B. Carpenter, it is possible that amongst the *Stromatoporæ* and their allies were included organisms of essentially similar structure, but differing in the fact that some of them were siliceous and others calcareous (just as a similar series of morphological types can be shown to have existed amongst the arenaceous and calcareous Foraminifera).

Fourthly. It may be maintained, as was originally supposed by Eichwald ('Lethæa Rossica,' vol. i.), and as was afterwards so forcibly urged by Von Rosen ('Ueber die Natur der Stromatoporen,' 1867), that the skeleton of *Stromatopora* was originally horny, and that the primitive horny fibres were replaced by silica or by carbonate of lime. This view we shall not discuss further, as the researches of Zittel and Sollas have completely destroyed all the collateral evidence upon which Von Rosen founded his views, and which was essential to the support of his argument.

In deciding which of the above views is correct, we have three kinds of evidence to consider, namely the mode of occurrence of the Stromatoporoids in the beds in which they are found and the condition of their associated fossils; the microscopic appearances of transparent sections; and, lastly, the composition of different specimens, as shown by the effects produced by the application of acids and by other modes of examination.

The evidence under the first head is of great importance, and far too little attention has hitherto been paid to it. So far as the facts at present in our possession go, the general evidence is altogether in favour of the view that *Stromatopora* and its immediate allies were originally calcareous. The ground for this assertion is the fact that (within our experience) specimens of *Stromatopora* and its allies are always found in a calcareous condition when the associated fossils are also calcareous, but that they are generally more or less siliceous where the associated and primitively calcareous fossils are to any large proportion silicified. Excellent examples of this are afforded by the occurrence of Stromatoporoids in the Silurian and Devonian deposits. Thus in the Silurian Limestones (such as the Trenton, Niagara, and Clinton Limestones), in which silicification is comparatively infrequent, the specimens of *Stromatopora* are generally calcareous, and in the Magnesian Limestones of the Guelph formation (Upper Silurian)

they resemble the other fossils in being converted into dolomite. Again, in the cherty limestones of the Corniferous series (Devonian), we find numerous Stromatoporoids in a siliceous condition, and we find at the same time that nearly all the associated corals, Brachiopods, and other originally calcareous fossils have undergone silicification. If we ascend, however, into the immediately overlying shales and impure limestones of the Hamilton group, we find an abundance of Stromatoporoids (sometimes specifically identical with those of the Corniferous) in the same completely calcareous condition as all the other fossils of the formation. Similar facts seem to be observable elsewhere, as shown by the fact that the Stromatoporoids of the Wenlock Limestone of Dudley, the Wenlock Limestone of Gotland, and the Devonian Limestones of Devonshire resemble the fossils associated with them in being calcareous*.

The microscopic characters of thin sections afford comparatively little help in determining whether *Stromatopora* was originally calcareous or siliceous. In no case, however, have we succeeded in observing that the laminæ or pillars were composed of distinct and separate siliceous granules; nor can any structure of a similar nature be detected by the microscope in siliceous examples of *Stromatopora* from which the matrix has been completely removed by the action of weathering or the use of acids. Such a construction, however, is very readily observable in the case of *Parkeria*.

Another fact of a very noteworthy character is brought out by an examination of thin sections of the Stromatoporoids with the microscope. In all cases alike, namely, whether the specimen be purely calcareous or partly calcareous and partly siliceous, the carbonate of lime forming the actual skeleton is invariably *granular*. In other words, the skeleton is never composed of crystalline calcite, but always of the granular ill-defined calcareous matter which we find also in the skeleton of the ordinary corals. The importance of this observation is much enhanced by the discovery made by Zittel (Neues Jahrb. für Mineralogie, &c. 1877) that

* Since writing the above, we have personally visited the Devonian Limestones of Devonshire, the Upper Silurian Limestones of Wenlock Edge and Woolhope, and the great "Eifelkalk" of Germany, from all of which we have made large collections of Stromatoporoids; and in all these localities we find the above conclusions confirmed in all particulars. That is to say, the Stromatoporoids are invariably calcareous where no silicification of the associated corals and shells has taken place.

some of the true siliceous Hexactinellid Sponges have their skeleton replaced by carbonate of lime, but that in these cases the replacing material has the form of *crystalline calcite.* This, therefore, we should be justified in expecting to find also the case if the Stromatoporoids had been primitively siliceous and had been replaced by lime; but in reality the calcareous skeleton is under no circumstances, so far as we have observed, crystalline. On the other hand, the granular appearance of the carbonate of lime is a very strong proof that it constituted the primitive skeleton of the Stromatoporoids.

As regards the actual *condition of preservation* in which specimens occur, we find that there are five different states in which the Stromatoporoids are found:—

(*a*) In the first place, many specimens not only have the skeleton entirely calcareous, but have the sarcode-chambers further filled with calcareous matter in the form of transparent calcite. This is the case with all specimens from beds where the fossils generally are unaltered, as in the Dudley Limestone (Wenlock) and the corresponding limestones of Gotland, as well as in the equivalent Niagara Limestone of North America. It is also the case, essentially, with the Stromatoporoids of the Guelph Limestones and of the Clinton formation of North America, though in these the sarcode-chambers are filled with a crystalline aggregate of dolomite instead of calcite.

(*b*) In the second place, many specimens are found in which the skeleton of the fossil is more or less completely calcareous, whilst the sarcode-chambers are infiltrated more or less completely with silica. When this is the case, decalcification, whether natural or artificial, and whether applied to thin sections, to polished surfaces, or to small fragments, results in the production of a siliceous structure representing the casts of the sarcode-chambers and interlaminar spaces, together, in some cases, with the canals connecting these. Transparent sections of similar specimens show, as a rule, however, that the infiltration with silica has not been absolutely perfect. On the contrary, the porous skeleton of the fossil seems to have been first infiltrated with water holding carbonate of lime in solution, resulting in the deposition of a thin layer of small crystals of calcite throughout the whole of the sarcode-chambers, and the space still left empty was subsequently filled with silica. This is beautifully shown by the polariscope in specimens of this nature, the actual calcareous

skeleton, with its delicate layer of calcite-crystals, remaining unchanged, whilst the siliceous infilling of the chambers is brilliantly coloured. Specimens of this kind, infiltrated with silica, but having their actual skeleton unchanged, are very common in the Corniferous Limestone of North America.

These specimens, moreover, prove the important fact that the silica filling the chambers and interspaces of the fossil is not amorphous organic silica, but crystalline doubly-refractive silica; for the use of crossed prisms produces the most brilliant play of colours in the siliceous infilling of the chambers, the variety and intensity of tints being fully equal to what we observe in crystals of quartz.

(*c*) In the third place, we find specimens in which the actual skeleton of the fossil is more or less completely converted into silica (often faintly granular under the microscope), whilst the chambers of the organism are filled with calcite. In these specimens decalcification, whether natural or artificial, results in the production of a reticulated siliceous framework, representing the true skeleton, the interspaces being hollow. Specimens of this kind are not unknown in the Corniferous Limestone of North America; but they lend no support whatever to the view that *Stromatopora* was originally siliceous, for this is precisely the state of preservation in which almost all the fossils of the Corniferous Limestone occur, such as Corals, Brachiopods, &c., which were undoubtedly calcareous to begin with. All these fossils, namely, have their primitively calcareous structure accurately replaced by silica (often of a granular appearance), whilst their cavities are filled with carbonate of lime. It should also be noticed that small specimens in this state of preservation, especially specimens mounted for microscopic examination, are not easily discriminated from similar fragments of specimens of the second group, where the skeleton is unaltered and the chambers have been filled in with silica. This is especially the case when decalcification, natural or artificial, has been produced, as the resemblance of the true silicified skeleton to the siliceous network representing the successive tiers of sarcode-chambers is much closer than might be imagined. It may safely be asserted, indeed, that it would be very difficult for any observer to discriminate with certainty between microscopic preparations belonging to these two groups unless he had previously seen the actual specimens from which they were taken, if it were not absolutely impossible. Against

this source of error, however, we have guarded by the personal preparation of our slides from specimens which we had previously subjected to a careful examination by means of polished sections and acids.

(*d*) In the fourth place, there occur specimens (especially in the Corniferous Limestone of North America) which unite in themselves both the last-mentioned states of preservation, the skeleton of the fossil in parts being calcareous, whilst the sarcode-chambers are infiltrated with silica; whereas in other parts the skeleton is siliceous and the chambers are filled with calcite. Specimens of this nature require no further notice here, as they teach us nothing that cannot be learned from an examination of specimens of either the second or third group.

(*e*) In the fifth place, we find a few examples in which not only is the skeleton siliceous, but the sarcode-chambers are likewise filled with silica. In these cases, of course, thin sections constitute the only mode of examination, as acids are wholly ineffective.

As regards the general conclusion to be drawn from the various classes of facts above enumerated, it appears to us to be unquestionable that the Stromatoporoids were originally *calcareous* in their composition. This conclusion seems to us to be rendered inevitable when we consider that specimens of the Stromatoporoids are almost invariably calcareous in beds in which the accompanying fossils are also generally unaltered, and that they are only found to be siliceous in strata in which the other fossils (undoubtedly calcareous to begin with) are silicified—that in no case known to us does microscopic examination show the skeleton to be composed of distinct siliceous spicules or of separate sand-grains—that many specimens are found in which the original spaces of the fossil are filled with silica, whilst the skeleton itself is more or less entirely calcareous—and that in many cases the original calcareous skeleton has clearly been coated to its most minute recesses with minute crystals of calc-spar before being finally infiltrated with silica. If we were to believe that *Stromatopora* was originally and essentially siliceous, we should have to believe that it had been, in innumerable instances, converted into *lime*. The researches of Zittel ("Die Hexactinelliden," Abhandl. der k. bayer. Akad. der Wiss. 1877) and of Sollas ("On *Stauronema*," Ann. & Mag. Nat. Hist. ser. 4, vol. xix. 1877) have, indeed, shown that the Hexactinellid sponges are occasionally more or less completely converted into carbonate of lime; so that

palæontologists can no longer refuse to recognize and take into account the possibility of the replacement of silica by carbonate of lime. In this particular case, however, we should be compelled to believe that this certainly unusual conversion of a siliceous skeleton into a calcareous one had taken place just in the very beds in which the fossils, as a rule, show no alteration whatever—beds like the Wenlock Limestone of Britain and Sweden, and the Trenton and Niagara Limestones and the Hamilton formation of North America. On the other hand, when we meet with Stromatoporoids with a siliceous skeleton, we should have to believe that this was their original constitution, and we should have to account for the fact that these siliceous specimens are almost, if not quite, exclusively found in strata in which the unquestionably calcareous corals and Brachiopods are for the most part also siliceous. The only other hypothesis, namely that the Stromatoporoids (like the Foraminifera) are sometimes calcareous and sometimes siliceous, we were at first not indisposed to accept; but the total absence of any composition out of distinct sand-grains in the silicified specimens, and the existence of specimens partly silicified and partly calcareous, have induced us to abandon this view. This view, however, might be easily entertained if due care were not taken to separate specimens showing the siliceous infilling of the sarcode-chambers from those in which the skeleton itself has been silicified.

Minute Stucture of the Stromatoporoids.

In studying the minute structure of any Stromatoporoid, it is necessary to make sections in two directions—namely, *vertically* or *radially*, at right angles to the concentric laminæ of the mass, and *horizontally* or *tangentially*, or parallel with the concentric laminæ *. Sections of the first order are easily prepared; but sections of the second order present greater difficulties, as the concentric laminæ are invariably more or less curved or undu-

* Owing to the very variable form of the colonies of the Stromatoporoids, the terms *vertical* and *horizontal* can hardly be used with propriety to designate the two kinds of sections above referred to, unless they are understood simply as expressing the relation of the sections to the concentric laminæ of the fossil. We prefer, therefore, to use the terms "*radial*" and "*tangential*," the former indicating all sections which are parallel with the "radial pillars," and which cut the concentric laminæ at right angles, whereas by the latter we understand all sections which are approximately parallel with the concentric laminæ, whatever may be the relation between the planes of these sections and the plane of the general mass from which they are taken.

lated, and it is impossible to make a section wholly in the plane of any single lamina or interspace.

In studying the minute structure of the Stromatoporoids, we have successively to consider the following points:—

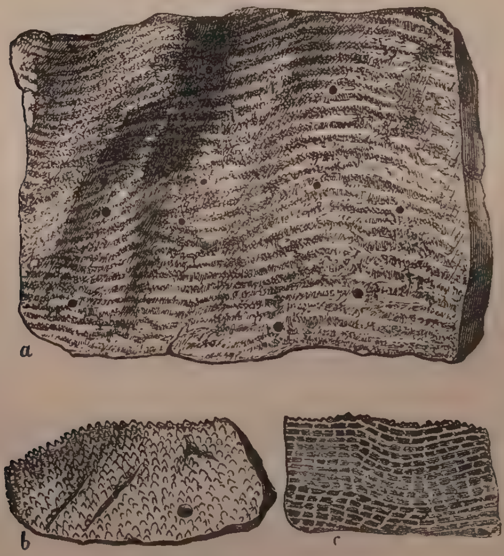
1. *The Internal Constitution of the Mass.*—If we make a *vertical* or *radial* section of any typical Stromatoporoid, such as *Stromatopora concentrica*, Goldf., we find that it is composed of curved, undulating, but essentially horizontal "laminæ," either spread out in mass or arranged concentrically round one or more centres, and having wider or narrower interspaces between them. The latter are crossed by vertical or "radial" pillars, placed at approximately similar distances, and dividing the "interlaminar spaces" into a number of minute compartments. A *horizontal* or tangential section of a similar form shows the transversely divided ends of the "radial" pillars, along with winding or reticulated lines representing the obliquely cut edges of successive undulating laminæ belonging to the horizontal series. In their *ultimate constitution* both the horizontal laminæ and the "radial" pillars are composed of minutely granular carbonate of lime, which shows no structure beyond the occasional presence of an indistinct reticulation, and which is entirely unaffected by polarized light. In sections of calcareous specimens, when of great thinness, the laminæ become more or less indistinct as a rule, and it is only in certain cases that they show perfectly distinct and defined outlines and do not exhibit blurred edges *. In some silicified specimens, on the other hand, the skeleton is brought out with great vividness between crossed Nicols, since it remains unaffected itself, whilst the filling of the spaces of the fossil exhibits a brilliant play of colours. Even in these cases, however, the actual laminæ and pillars are often invested by an irregular crystalline layer or coating of carbonate of lime, which remains uncoloured.

2. *The Nature of the Radial Pillars.*—The vertical or radial pillars of a typical Stromatoporoid have most generally been regarded as *tubes*. So far, however, as all ordinary examples go, we can entirely confirm Von Rosen's observations ('Ueber die Natur der Stromatoporen,' 1867), which clearly show that these pillars are

* For this reason, in dealing with the calcareous Stromatoporoids (as apart from silicified specimens), the best results are obtained when the section has not been cut down to an excessive degree of tenuity, and when a low magnifying-power (a 2 to 4-inch objective) is used.

solid and imperforate. In no case have we certainly succeeded in detecting any central cavity in the radial pillars, when their truncated ends are examined in tangential or oblique sections. The tubercles which stud the surface of many forms are sometimes seen to be perforated by a central aperture; but we have never noticed this appearance except upon the weathered and partially exfoliated surface of *silicified* specimens, and even in these many of the tubercles in question are undeniably imperforate. We are therefore disposed to explain this appearance as being due, not to the real existence of a central canal in the radial pillars, but rather to the fact that the pillars have been imperfectly silicified, and the unchanged carbonate of lime in their interior has been subsequently dissolved out. In general form, the radial pillars are usually expanded at the points where they coalesce with the horizontal laminæ which they connect, and attenuated in their central portions, and, though occasionally oblique, they mostly have a vertical direction. In some cases they are partially rudimentary,

Fig. 2.



Stromatopora tuberculata.

a. Under surface, of natural size, showing the wrinkled basement-membrane and openings of water-canals. *b.* Portions of upper surface, enlarged. *c.* Vertical section, to show internal structure, magnified. From the Corniferous Limestone, Canada. (After Nicholson.)

falling short of the horizontal lamina above that from which they spring. In such cases they appear in weathered specimens as so many elevated tubercles on the surfaces of the laminæ. In some cases, which will be afterwards alluded to, they are replaced by downward inflexions of the horizontal laminæ themselves; and in some aberrant forms, which will be noticed hereafter, they are entirely absent. Though they may be accidentally superimposed upon one another in successive interlaminar spaces, they are clearly independent of one another in origin, and are severally confined to their own interspaces. Even, therefore, if they were perforated centrally, they could not be compared properly with the tubes of *Tubipora* or *Fistulipora*.

3. *The Structure of the Horizontal Laminæ.*—The horizontal laminæ which form the greater part of the mass of a typical Stromatoporoid appear in vertical sections as so many continuous concentric layers, whilst in horizontal sections they are necessarily only visible where their cut edges may be brought into view in consequence of their undulations. They can therefore be only to a certain extent studied by means of thin slices prepared for the microscope, since vertical sections simply cut them transversely and leave many points unelucidated; whilst horizontal sections cannot be made to show more than the most minute portions of the surface in the plane of any single lamina. We have therefore to rely principally upon the appearances presented by the horizontal laminæ as exposed on the surface of unaltered calcareous specimens, or, still better, as seen in weathered or decalcified specimens in which the skeleton has been silicified. Even when examined, however, both by sections or by weathered specimens, even when beautifully preserved, the horizontal laminæ do not present such clear or such uniform appearances that a positive opinion as to their minute structure can be rashly formed. On the contrary, it would appear that the actual structure of the horizontal laminæ is different in different Stromatoporoids.

In a great many Stromatoporoids (such as *Stromatopora striatella*, D'Orb., *S. granulata*, Nich., *S. tuberculata*, Nich., &c.) the surfaces of the horizontal laminæ as exposed on weathered surfaces are seen to be studded with elevated granules or tubercles, sometimes extremely minute, sometimes large, papilliform, and prominent. These elevations are sometimes simply rounded; at other times they are confluent, and form vermiculate

eminences. Some of them are apparently broken radial pillars, and perhaps they are in general incipient structures of this nature. Most of these tubercles are clearly imperforate; but it is not uncommon in silicified examples, as before remarked, to find a variable number of the tubercles perforated by a central tube. If these tubes are natural, then they must serve to place the successive interlaminar spaces in communication; but, as above stated, we have only detected them in silicified examples, and we are inclined to think that they are due to imperfect silicification. In the tuberculate Stromatoporoids just alluded to (such as *S. granulata*, Nich.), whether we take calcareous or silicified examples, and however exquisite may be the state of preservation, we have hitherto failed to satisfy ourselves of the existence of any openings piercing the laminæ between the tubercles, and placing successive interlaminar spaces in communication, though it seems most likely that such really exist.

On the other hand, there are forms (such as *Stromatopora nodulata*, Nich., and *Syringostroma densa*, Nich., and various forms from the Devonian limestones of Devonshire and of the Eifel) in which the surfaces of the horizontal laminæ are smooth and exhibit no tubercles, while they are rendered minutely porous by the presence of innumerable apertures. These openings may be extremely minute, or they may be of comparatively large size and of a vermiculate character, in which latter case the horizontal laminæ assume a kind of trabecular or loosely reticulate structure. There cannot, therefore, be in these cases any doubt that the interlaminar spaces communicate with one another directly by canals passing vertically through the horizontal laminæ, and entirely independent of the radial pillars. That some such communication, to a greater or less extent, exists in all the Stromatoporoids appears to be exceedingly probable, though we have failed to satisfy ourselves of its existence in some forms. One of the difficulties connected with this is that of demonstrating any perpendicular tubules passing through the horizontal laminæ in *transparent vertical slices* of the fossil. Sections of this nature *ought* to show these tubuli if they are present at all. In very many cases, especially in unaltered calcareous specimens, the substance of the horizontal laminæ in very thin sections becomes so ill-defined that, even by the use of the polariscope, it is impossible to make out whether tubules are present or not. Even in cases where we *know* that the interlaminar spaces communicate

in this manner (as in *S. nodulata*, Nich.), thin vertical sections afford no conclusive evidence of the existence of these connecting-tubes—the cut edges of the horizontal laminæ appearing as granular or subreticulate *continuous* lines, with only occasionally faint indications of a vertical tubule marked out by clear calcite. In *Syringostroma densa*, again, where the horizontal laminæ are similarly perforate, the substance of the fossil is so dense that the evidence of vertical tubules is unsatisfactorily shown by vertical sections, though there are undoubted indications of their existence. There are also indications of the presence of similar vertical tubes in *Clathrodictyon cellulosum*, Nich. & Murie, though these also are but obscurely marked. Some further evidence on this point (though likewise unsatisfactory) may be derived from the examination of specimens which have preserved their calcareous skeleton but have had their sarcode-cavities infiltrated with silica. If we examine a vertical polished section of such a specimen by means of a strong light reflected from the surface, and by the help of a lens, we can sometimes satisfy ourselves that the sarcode-chambers of successive interlaminar spaces are connected by perpendicular tubuli which have been filled with silica, and thus take on a higher polish than the calcareous and unchanged skeleton itself. In decalcified examples of similar specimens it is also sometimes possible to trace minute threads of silica proceeding from the rounded masses of silica which represent the original sarcode-chambers. This we observed with especial distinctness in a specimen belonging to Principal Dawson, which Dr. W. B. Carpenter was so kind as to allow us to examine.

Another question of importance is as to whether the horizontal laminæ possess any system of tubuli running horizontally, and therefore approximately parallel with their surfaces, in their actual substance. Our investigations on this point lead us to believe that no such canal-system exists in the substance of the concentric laminæ. In some specimens, in which the skeleton has been silicified and the calcareous filling of the chambers has been dissolved out, the cut edges of the laminæ as exposed in vertical sections have a cellular structure, but it cannot be said whether this is due to the presence of horizontal tubules or to the existence of the vertical tubules before mentioned, or whether, rather, it may not be due simply to imperfect silicification. The last view seems to us most probable. Many forms, again (such as the species of *Syringostroma* and *Cœnostroma*), possess a system of branched

or radiating canals or grooves which are approximately horizontal, and which are arranged in minor systems round numerous secondary centres. These canals or grooves, however, as we shall hereafter show, have no distinct walls, are of comparatively large and not microscopic dimensions, and perforate the horizontal laminæ obliquely, a large portion of their course being thus in the interlaminar spaces. In fact they appear to be often confined to a single interlaminar space, and thus to be more of the nature of branched *grooves* on the surfaces of the horizontal laminæ than actual canals. In no case, certainly, do these canals run *in* the horizontal laminæ, so that they do not constitute a canal-system comparable to microscopic tubuli of certain of the Foraminifera. Principal Dawson ('Dawn of Life,' p. 159) describes a specimen of *Cœnostroma* in which "the plates are traversed by tubes or groups of tubes, which in each successive floor gave out radiating and branching canals exactly like those of *Eozoön*, though more regularly arranged." We have not, however, seen any traces of these in any of the specimens which we have examined; and it is possible that Dr. Dawson is merely alluding to the radiating canals which are found in *Cœnostroma*, *Caunopora*, and other forms, and which, as we have remarked, do not properly form a canal-system in the substance of the skeleton of the fossil itself.

4. *The Sarcode-chambers.*—The general form and arrangement of the sarcode-chambers of the typical Stromatoporoids can be best studied in naturally or artificially decalcified specimens in which the skeleton has been silicified, or, on the other hand, in decalcified specimens in which the skeleton has remained calcareous whilst the cavities have been infiltrated with silica. In the first class of specimens we find the horizontal laminæ to be separated by spaces of very various width in different species, these interspaces being in turn broken up at shorter or longer intervals by the radial pillars. In the second class of specimens we get *casts* in silica of the sarcode-chambers, and we can thus study their general form and arrangement more minutely. In these specimens we find that each interlaminar space, though on the whole continuous, is really composed of a number of separate rounded chambers, connected by wide openings and marked off by the radial pillars. Hence the siliceous cast of a single interlaminar space presents us with a layer of rounded oval or circular siliceous masses, connected with one another on all sides by stolons of silica of considerable size, and separated by small perforations

placed at their angles, these latter being the vacant spaces left by the dissolution and removal of the radial pillars.

5. *Radiated Water-canals.*—In a large number of Stromatoporoids the entire mass is perforated at intervals by numerous systems of horizontal or slightly oblique water-canals, as has been already alluded to. These canals usually radiate from a large number of independent centres, each of which is elevated above the surface, in many instances, as a conical eminence of greater or less height. In weathered specimens in which the surface is shown, or in horizontal section, these canals are often admirably displayed, and they are seen to bifurcate frequently as they diverge from their respective centres. We have not been able to show that they start in a median canal except in some cases; and though their course is approximately parallel with the concentric layers of the mass, they are usually slightly oblique, and therefore pass from one interlaminar space to another, perforating the laminæ themselves in an oblique manner. They are not bounded by definite walls, and they can hardly be regarded in any proper sense as being canals which run in the actual skeleton. These

Fig. 3.

Stromatopora Hindei.

a. Upper surface of a portion, natural size. *b.* Vertical section of same, showing internal structure, enlarged. *c.* Enlarged view of a piece of the upper surface. From the Niagara Limestone. (After Nicholson.)

radiating canals have been considered a generic character (distinguishing *Cœnostroma*); but they are present in forms of very different affinities, and it does not appear to us that they can be used as a ground of generic distinction. They are especially well developed in forms such as *Stromatopora constellata*, Hall, *S. typica*, Von Rosen, *S. astroites*, Von Rosen, *S. elegans*, Von Rosen, *S. Schmidtii*, Von Rosen, *S. granulata*, Nich., *Caunopora planulata*, Hall & Whitf., *Stromatopora* (*Cœnostroma*) *incrustans*, H. & W., *S.* (*Cœnostroma*) *solidula*, H. & W., *Syringostroma densa*, Nich., and *Syringostroma columnaris*, Nich., &c. In the forms which one of us has termed *Syringostroma* (Nich. Pal. Ohio, vol. ii.) these radiating canals are of specially large size, and in vertical sections their cut ends are conspicuously seen as so many large rounded apertures.

6. *Vertical Water-canals.*—Many Stromatoporoids show superficial openings of very considerable size, which are apparently the apertures of canals leading through the mass in a direction upon the whole more or less perpendicular to the concentric laminæ of the mass. These canals have no distinct walls, and their apertures vary in size from half a line or less up to a line or more. Their function can hardly be any other than that of conducting the external water into the interior of the mass, or, as is more probably the case, of carrying off the water which has circulated through the colony, and their external openings have been compared with the "oscula" of the Sponges. In many forms these openings have not been detected at all; but they are very well marked in others (*e. g.* in some specimens of *Stromatopora striatella*, D'Orb.?, in *S. Hindei*, Nich., *S. tuberculata*, Nich., *S. ponderosa*, Nich., and *S. ostiolata*, Nich.)*.

In a hitherto undescribed Stromatoporoid from the Trenton Limestone, which appears to be clearly of generic importance (*Stromatocerium*, Hall?), the entire mass is perforated by vertical canals, which are destitute of walls, and which are placed close together and appear to communicate with large and irregular lacunæ in the mass, now filled with calc-spar. As will be subsequently mentioned, this singular form differs from all the normal Stromatoporoids, not only in the number and closeness of the canals just spoken of, but also in the total absence of vertical

* These tubes have been supposed to be simply the work of boring Annelids or other organisms; but we cannot accept this view, and their number and regularity of arrangement in *S. ostiolata*, Nich., would conclusively prove that they belong, whatever their nature may be, to the Stromatoporoid itself.

pillars crossing the interlaminar spaces, and in some other characters as well. Having seen no example of this species in which the surface is weathered, we are unable to say how these canals appear superficially; but in horizontal sections they seem to be generally oval or elongated canals or wall-less spaces, freely opening into the interlaminar spaces.

7. *Tubes of* Caunopora.—Of a very different character to the preceding are the vertical tubes found in the genus *Caunopora*. The only example of this genus that we have been able to examine by means of microscopic sections is *Caunopora placenta*, Phill., from the Devonian rocks of Devonshire. In this form the general structure of the mass is very similar to that of a typical *Stromatopora*, such as *S. striatella*, D'Orb., except that the radial pillars are not so well developed. There is, however, the special feature that the entire mass is perforated by numerous discontinuous (?) vertical tubes penetrating the horizontal laminæ at right angles. These tubes have strong calcareous walls, are about ½ line in diameter, have no vertical septa, but sometimes exhibit transverse calcareous plates, which look like continuations through them of the horizontal laminæ. The tubes are also sometimes connected by transverse tubular canals of considerable size. From the general form of these tubes, from their strong calcareous walls, and from the occasional presence of lateral connecting-tubes, we were led to think it possible that *Caunopora* might have been founded upon species of *Stromatopora* which had grown round and gradually enveloped a colony of *Syringopora*. Some silicified specimens of a *Caunopora* from the Devonian of Canada certainly look very like this. The tubes of *Caunopora*, however, are hollow, or at most have a few simple transverse tabulæ; and we have seen no traces in them, either in vertical or horizontal sections, of the *infundibuliform tabulæ* so characteristic of the *Syringoporæ*. We have also many silicified specimens of *Caunopora* (*Stromatopora*) *perforata*, Nich., in which the surface, with the openings of these tubes, is well seen. In this species, the entire fossil forms a thin and extended expansion, and the mouths of the tubes are all slightly elevated above the surface. Had the fossil grown round a pre-existent *Syringopora*, it is hardly possible for it to have presented these characters.

For the above reasons we are inclined at present to reject the view originally put forth by Ferd. Roemer, and subsequently adopted by Von Rosen, that *Caunopora* is founded upon Stroma-

toporoids which have grown parasitically upon colonies of *Syringopora*. At the same time, we desire to speak with diffidence upon this point, as we should require more material than has as yet been available to us before arriving at a final and positive conclusion*.

8. *Concentric Arrangement of the Chambers round Vertical Columns.*—Most of the Stromatoporoids show a tendency to a concentric arrangement of the horizontal laminæ round an indefinite number of minor centres, this being especially well seen in weathered and silicified specimens, though others exhibit little or nothing of this peculiarity. In *Syringostroma columnaris*, Nich., however, and in an undescribed Stromatoporoid (which we shall name *Stylodictyon retiforme*) from the Hamilton formation of Canada, this tendency is especially well marked, and is accompanied by the feature that the minor centres round which the chambers are arranged have the form of vertical columns, which run through the mass in a perpendicular direction and attain a very considerable size (from ½ to 1 line in diameter). In the Hamilton species just mentioned, these columns (which must not be confounded with the vertical pillars crossing the interlaminar spaces) are composed of reticulate calcareous matter, more dense by far than the general mass, and sometimes traversed by a vertical canal in the centre. In *Syringostroma columnaris* the columns are composed centrally of granular calcareous matter, apparently quite imperforate and not reticulate, placed on an average about one line apart. Whatever be the minute structure of the columns, the chamberlets are arranged round them (as seen in horizontal sections) in from two to four concentric rows, the interspaces between these being filled up with the ordinary reticulate structure of *Stromatopora*.

9. *Departures from the ordinary Type of* Stromatopora.—All the typical forms of the Stromatoporoids, as we have seen, are composed essentially of a system of more or less porous or reticulate horizontal layers separated by interlaminar spaces, which in turn are crossed by numerous solid calcareous pillars having a vertical or radial direction. There are, however, several departures from

* Since the above was written we have obtained a very extensive series of *Caunoporæ* from the Devonian Limestone of Devonshire. These we have not yet had time to investigate microscopically; but an examination of their characters, especially as shown by cut and polished specimens, enables us to affirm with certainty that the tubes of *Caunopora* unquestionably belong to the organism itself, and that they have no connexion whatever with *Syringopora*.

this state of things amongst fossils clearly referable to the same great systematic group, the following being the most important:—

(*a*) In a Stromatoporoid already referred to from the Trenton Limestone of North America, we find various remarkable peculiarities. In the first place, whilst the general aspect of the fossil is unmistakably Stromatoporoid, we find that it possesses only the crowded concentric laminæ which characterize the typical Stromatoporoids. These horizontal laminæ are of considerable thickness, and are separated, as usual, by well-marked interlaminar spaces; but the latter are quite open, and there is a total absence of the vertical or radial calcareous pillars which occur in the normal Stromatoporoids. Not only are the radial pillars absent, but the whole mass is perforated by innumerable vertical canals, which are *destitute of walls*, and which open directly into the successive interlaminar spaces, which they penetrate, as well as into irregular open spaces or lacunæ in the general laminated skeleton. As seen in vertical sections, this form differs from the normal Stromatoporoids in the absence of the radial pillars and in the presence of the numerous vertical and large-sized canals which divide the horizontal laminæ into so many short sections of an oblong form; whilst in horizontal slices we no longer see the truncated ends of the radial pillars. On the contrary, horizontal sections show us nothing but the irregularly and obliquely-cut edges of the horizontal laminæ, often arranged concentrically round minor centres, and sometimes showing indications of a minute canal-system traversing their substance. This form is tolerably abundant in the Trenton Limestone, and we have obtained it from several localities. It is clearly generically distinct from the normal Stromatoporoids, and must receive a distinct name. It is, however, very probably the form upon which Hall founded his genus *Stromatocerium*, and we would propose to revive this name for it. Hall's *Stromatocerium rugosum* was obtained from the Birdseye Limestone of the State of New York, which is only a subdivision of the Trenton; and as we are acquainted with no typical form of *Stromatopora* (indeed with none but this) as occurring in this formation, it is highly probable that our specimens are identical with this. Hall abandoned his generic title simply from the general resemblance of his specimens to *Stromatopora*, in the broad sense of the term; and our specimens certainly cannot be referred to *Stromatopora* in the restricted sense of the name. Whether our form is specifically identical with Hall's *Stromato-*

cerium rugosum or not, is a point which we have no means of determining.

(*b*) Another singular form, which we propose to distinguish by the generic title of *Pachystroma*, and of which we possess many specimens from the Niagara Limestone of Canada, though clearly Stromatoporoid in its general characters, exhibits features even more singular than the preceding. The fossil exhibits the general form of the Stromatoporoids, consisting of irregular subhemispheric masses, composed conspicuously of numerous concentric calcareous layers; but these layers are of comparatively enormous thickness (averaging about a line, but sometimes double this thickness), and though perfectly distinct from one another, they are either in direct contact, or they are only separated from one another by irregular and narrow intervals. There are therefore no "interlaminar spaces" in the proper sense of the term, and necessarily no "radial pillars." When examined by means of transparent vertical sections, the great concentric laminæ are seen to be composed of porous calcareous tissue, principally composed of vertical irregular fibres placed at some distance from one another, and only brought clearly into view by the use of polarized light. The concentric laminæ are also perforated by numerous delicate, but irregular and generally remote, vertical tubules; but their surfaces, as seen in fractured or weathered specimens, cannot be shown by the use of a hand-lens to be minutely porous, though doubtless really so. The surface of weathered specimens also shows radiating, branched, "subdermal" canals, placed round numerous independent centres, precisely as in the so-called *Cœnostromæ*. Horizontal sections show simply a loosely reticulate calcareous network, of an irregular character and granular structure, with oblique sections of the radiating water-canals. In these, however, as in so many of the thin sections of the calcareous specimens of the Stromatoporoids, the use of polarized light is almost essential to a proper determination of the intimate structure.

(*c*) In another group of unquestionable Stromatoporoids, the general structure is extremely like that of the typical *Stromatoporæ*; but the horizontal laminæ and radial pillars are completely merged in one another, so as to be incapable of separation as distinct structures; though both of them exist in a modified form, and the interlaminar spaces are present as well. One of the forms belonging to this group is very common in the Clinton formation in North America, and often attains very considerable

dimensions, forming flattened elliptical masses from six inches to a foot in diameter; and the same form is found in the Niagara Limestone in Canada*. When superficially examined, this species is almost undistinguishable from *Stromatopora striatella*, D'Orb., which it closely resembles in the extreme closeness and density of its reticulate tissue. When examined, however, by means of thin vertical sections, this form is found to differ fundamentally from *S. striatella* in not consisting of distinct horizontal laminæ, separated by interspaces crossed by radial pillars. On the contrary, the entire structure is minutely vesicular, like a *Cystiphyllum*, but much more delicate, composed of innumerable oval vesicles placed in concentric lines, and very often opening into each other at both extremities. In other words, the horizontal laminæ are inflected so as to form a number of small oval cavities, which may or may not be separated from one another; and when these inflections are so pronounced as actually to separate contiguous laminæ, then they represent the "radial pillars" of the normal Stromatoporoids.

Another form belonging to this group is a large massive Stromatoporoid from the Corniferous Limestone of North America, of which we possess numerous well-preserved examples, all of which, however, are infiltrated with silica, the skeleton itself generally remaining calcareous. In this form the minute structure is essentially similar to that of the preceding, but on a comparatively gigantic scale. The entire mass is composed of oval or elongated cells with calcareous walls, generally about three to a line, placed in horizontal rows, and sometimes opening one into the other by wide apertures. Though the longitudinal apposition of the cells in concentric and parallel rows gives the appearance of there being distinct horizontal laminæ, each vesicle has its own proper walls as a rule, as is distinctly shown in many instances where two vesicles are placed end to end without their walls coalescing. The vesicles, however, may be regarded as produced by the rapid undulation and inflexion of the horizontal laminæ, the "radial pillars" not existing as distinct structures. Horizontal sections show a similar network of oval vesicles

* We have recently found a precisely similar form to be of quite common occurrence in the Wenlock Limestone of the West of England; and though we have not yet been able to make thin slices of this, we are led to think it possible that the form usually termed *Stromatopora striatella*, D'Orb., may really be none other than this.

with wide and open meshes. When examined with low powers, and especially with the use of polarized light, the walls of the vesicles sometimes exhibit the appearance of being traversed by numerous vertical tubuli, placing contiguous vesicles in successive layers in direct communication. This structure would be very closely similar to that of the Foraminiferal genus *Tinoporus*; but we cannot assert positively that it exists, though we have paid special attention to this point. The surfaces of the layers in this form, when exposed in weathered specimens, usually show nothing but the oval siliceous casts of the sarcode-chambers, separated by vermiculate and anastomosing depressions. These two forms appear to us to be so fundamentally distinct from *Stromatopora* proper, in spite of their close general resemblance to it, that we propose to give them a special name, viz. *Clathrodictyon*. We propose, further, to name the Clinton species *C. vesiculosum*, and the Corniferous form *C. cellulosum*.

(*d*) Lastly, we may note the occurrence of forms in most respects resembling the Stromatoporoids in appearance and general arrangement, but having merely a loosely reticulate and indefinite minute structure. The only specimen we have of this group is from the Cincinnati group (Lower Silurian) of Waynesville, Ohio, and is completely silicified, the skeleton being converted into flint, and the interspaces filled with transparent silica. In general form the fossil is Stromatoporoid, composed of concentric shells, and having an undulating surface, elevated into conical prominences. Internally the skeleton is irregularly reticulate and porous, traversed by canals which often radiate from minor centres. Our investigations of this specimen, though sufficient to indicate its distinctness as a separate type, have not been carried so far as to justify us in giving it a separate title. Forms of an apparently similar nature occur in the Corniferous Limestone (Devonian) of Ohio, but we have not hitherto been able to examine these minutely.

10. *Classification and Types of the Stromatoporoids.*—The Stromatoporoids have generally been grouped and classified in accordance with certain well-marked external features, such as the presence or absence of radiating horizontal water-canals, the presence of vertical tubes penetrating the mass, &c. These characters are sometimes sufficient (as in the case of the vertical canals of *Caunopora*); but more minute examination has shown that others, formerly relied upon as tests of generic distinction,

are common to forms which in intimate structure are very different. Thus the radiating surface-canals which induced Winchell to found the genus *Cœnostroma* are found in forms having the intimate structure of *Stromatopora*, in the utterly abnormal *Pachystroma*, and (in an especially well-marked form) in the group of Stromatoporoids designated by one of us *Syringostroma* (Nicholson, Pal. Ohio, vol. ii.). It appears, therefore, that we must fall back in classifying the Stromatoporoids upon their ultimate constitution as shown by the microscope, discarding such general features as the presence of radiating surface-grooves and water-canals, and relying solely upon the different modes of arrangement of the minute elements of the skeleton. In this case, such genera as *Cœnostroma*, Winchell, and *Syringostroma*, Nich., will have to be abandoned and redistributed, or possibly retained as subgenera. In the following pages we shall bring forward a provisional arrangement of the Stromatoporoids, based upon their minute structure, and excluding in the meanwhile all types which do not appear to us to be easily recognizable.

(*a*) Stromatopora, Goldfuss.

(Petrefacta Germaniæ, 1826.)

Skeleton ("sarcodeme") consisting of concentric calcareous laminæ, separated by distinct "interlaminar spaces," which are crossed by numerous vertical "radial pillars." In some cases there are radiating water-canals and surface-grooves placed round minor centres. Sometimes there are seen on the surface the openings of large water-canals ("oscula").

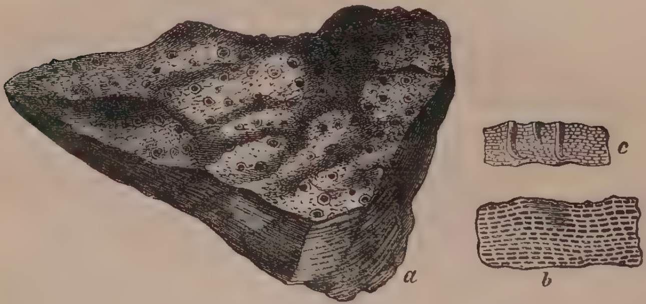
Habit.—Forming irregular masses, sometimes with a foreign body as a nucleus; spreading out into extended expansions, covered inferiorly by a thin striated calcareous membrane ("epitheca"), or growing in thin layers parasitically upon foreign objects.

Type.—*Stromatopora polymorpha*, Goldfuss.

We have not personally had the opportunity of examining specimens of *S. polymorpha*, but judging from the figures and descriptions of authors, and especially from those of Von Rosen, there can be no doubt that its minute structure is as indicated in the above definition. If this be the case, then *Stromatopora* proper will include all those Stromatoporoids in which the skeleton consists of concentrically disposed horizontal laminæ, the

interspaces between which are crossed with more or less regularity by well-developed and complete radial pillars, producing the tissue of regular quadrangular cells which forms such a characteristic feature in vertical sections of forms of this type. Among the forms which we have examined ourselves, we may mention as belonging to the same type—*S.* (*Cœnostroma*) *granulata*, Nich., *S. tuberculata*, Nich., *S. ostiolata*, Nich., *S. nulliporoides*, Nich., *S. nodulata*, Nich., and *S.* (*Cœnostroma*) *discoideum*, Lonsd. sp. It appears, also, that *S. typica*, Von Rosen, and *S. expansa*, Hall and Whitfield, should be placed here; and there are doubtless many other forms with whose internal structure we have but an imperfect acquaintance.

Fig. 4.



Stromatopora (*Caunopora*) *perforata*.

a. Fragment showing the osculiferous upper surface, of natural size. *b*. Vertical section exhibiting internal structure, magnified. *c*. Another vertical section, very slightly enlarged, showing more especially the perpendicular canal-structure. From the Corniferous limestone, Port Colborne, Ontario. (After Nicholson.)

While all the above agree in the peculiar form and arrangement of the minute elements of the skeleton, they present various differences in structure, some of which will probably be found to be of sufficient importance to serve as a basis for the establishment of subgenera.

S. polymorpha, Goldfuss, and *S. typica*, Von Rosen, exhibit very clearly two sets of pores, which penetrate the concentric laminæ and open on the surface. Most of these pores are very minute, and may perhaps be compared with the "inhalant apertures" or "pores" of Sponges; while others are much larger,

are often placed at special points, and may correspond with the "exhalant pores" or "oscula" of Sponges. Both also exhibit the radiating surface-grooves and canals which are present in the so-called *Cœnostromæ*. Similar radiating canals are present in *S.* (*Cœnostroma*) *discoidea*, Lonsd., *S. granulata*, Nich., and *S. tuberculata*, Nich., though in these instances they appear to be confined to the superficial layer, and to be mere subdermal grooves. In other cases no such structure can be detected. In *S. ostiolata*, Nich., there are well-developed and regularly disposed apertures of large size ("oscula"?). In some cases (e. g. *S. nodulata*, Nich., and *S. nulliporoides*, Nich.) the surface is smooth; but it is generally covered with miliary granules, tubercles, or vermicular ridges.

The *geological range* of *Stromatopora* proper, so far as our own personal observations go, is Upper Silurian and Devonian.

(*b*) CAUNOPORA, Phillips.

('Palæozoic Fossils of Cornwall,' &c., 1841.)

Skeleton ("sarcodeme") massive or expanded, its general structure very similar to that of *Stromatopora* proper, but the concentric laminæ minutely undulated and inflected, and the radial pillars often more or less rudimentary (as in *Clathrodictyon*). The reticulated skeleton is perforated by large tubes half to one line in diameter), which have strong calcareous walls, are open throughout, or crossed by a few remote horizontal partitions, are sometimes connected with one another by lateral tubes, are in the main perpendicular to the concentric laminæ, and finally open on the surface in the form of large rounded apertures.

Type.—Caunopora placenta, Phill.

In this section we must also place *C.* (*Stromatopora*) *perforata*, Nich., from the Corniferous Limestone of North America. The chief point by which this type is distinguished from *Stromatopora* proper is the presence of vertical tubes, with definite walls, perforating the entire mass. As has been previously stated, the microscopic examination of the only Devonshire example of Phillips's *C. placenta* at our disposal does not allow us at present to accept Ferd. Roemer's suggestion that the genus is founded upon specimens of *Stromatopora* which have enveloped a coral *.

* As we have before remarked, we are now in possession of a fine series of specimens of *Caunopora* from the Devonian limestone of Devonshire, which seem to render it certain that the tubes of this form are really part and parcel of the Stromatoporoid itself, and that they are not due to the fact that the latter has simply enveloped a coral of the type of *Syringopora*.

The only coral which occurs in the same strata, and which presents any resemblance to the tubes of *Caunopora*, is *Syringopora*; and we most freely admit that there is a singular resemblance between the two. Microscopic sections of *Caunopora* show, however, that its tubes want all the characteristic internal structures of *Syringopora*; so that we must provisionally conclude that we have to deal here with a structure really belonging to the Stromatoporoid, and certainly sufficient to warrant its generic separation from *Stromatopora*.

The range of *Caunopora*, so far as we can speak ourselves, is exclusively Devonian.

(*c*) Clathrodictyon, Nich. & Murie.

Skeleton ("sarcodeme") massive, closely resembling *Stromatopora* in superficial aspect and general appearance and structure, but differing in the fact that the concentric laminæ are minutely undulated, and inflected at short intervals, so as to give rise to successive layers of oval or rounded cells or vesicles, which are usually distinct, but at other times open into one another by the imperfection of their lateral boundaries. There are thus no "radial pillars" as independent structures; but their place is taken by partial or complete inflexions of the horizontal laminæ bounding the interlaminar spaces, which are bent in such a way as to divide the space into complete or incomplete oval compartments. Horizontal section simply reticulate. Surface tuberculate.

Type.—*Clathrodictyon vesiculosum*, Nich. & Murie.

Geological Range.—Upper Silurian and Devonian.

[Though it is no part of the object of the present paper to enter into the characters of species, we may as well append here brief specific diagnoses of the only two forms of this group known to us, both of which are new.]

Clathrodictyon vesiculosum, Nich. & Murie.

Spec. char.—Skeleton in the form of cake-like expansions, from three inches to a foot in diameter, one to two inches in thickness centrally, but thinning out towards the circumference. Upper surface irregularly undulating, and exfoliating concentrically round the elevated points. Surface smooth. Internal structure of exceedingly fine and close-set horizontal or slightly undulating laminæ, of which about twenty or twenty-five occupy the space of one line (counting in the intervening interlaminar spaces as well). The interlaminar spaces divided into minute lenticular cells formed by curved inflexions of the horizontal laminæ.

The entire structure of the fossil, as viewed in vertical sections, resembles that of a *Cystiphyllum*; but the vesicles are so minute that in merely polished slices the hand-lens will hardly reveal any structure at all. In its general characters the fossil resembles that usually labelled *Stromatopora striatella*, D'Orb.; but it is densely and closely vesicular in structure, and the examination of thin sections with the microscope at once shows its entire distinctness from *Stromatopora* proper.

Form. & Loc.—Common in the Clinton formation of Yellow Springs, Ohio (infiltrated with dolomite); not so common in the Niagara Limestone of Thorold, Ontario. Upper Silurian. *Coll.* Nicholson.

CLATHRODICTYON CELLULOSUM, Nich. & Murie.

Spec. char.—Skeleton forming irregular masses or thick expansions, which attain a considerable size. Horizontal laminæ about four in the space of one line, inflected so as to form complete or incomplete partitions, which divide the interlaminar spaces into a number of irregularly oval vesicles, of which about three occupy the space of one line. Surface tuberculate or granulated, the tubercles apparently occasionally perforated.

This beautiful species was first discovered by our friend Mr. George Jennings Hinde, who at once recognized its distinctness from previously recorded forms, and pointed out the fact to one of the present writers. All the specimens which we have seen are either actually silicified, or are infiltrated with silica, the skeleton remaining in the latter case calcareous. In excessively thin vertical sections, the walls of the vesicles of the mass, in parts, present the appearance of being perforated by minute tubuli; but we have been unable to satisfy ourselves of the reality of this appearance, though, if established, this would throw an important light upon some questions as to the minute structure of the Stromatoporoids.

Form. & Loc.—Common in the Corniferous Limestone (Devonian) of Wainfleet, Ontario. *Coll.* Hinde and Nicholson.

(*d*) STYLODICTYON, Nich. & Murie.

Skeleton composed of laminæ and interlaminar spaces, the latter crossed by radial pillars. The entire mass is supported upon a system of vertical columns, which may be composed of comparatively dense calcareous tissue, or may, in other cases, be loosely reticulated, and which are occasionally occupied by vertical canals. Round these vertical columns the horizontal laminæ and interspaces are concentrically arranged in successive layers; and the more or less extensive spaces between these are filled up with reticulated tissue disposed in horizontal layers or irregularly. Radiating water-canals may or may not be present.

Type.—Stylodictyon (Syringostroma) columnare, Nich.

In the type species (Pal. Ohio, vol. ii. p. 253) the vertical pillars which traverse the mass are seen in transverse sections to be solid, and to be composed throughout of granular carbonate of lime. The chambers are arranged concentrically round the pillars; and there is an extremely well-developed system of water-canals arranged in radiating groups, the cut ends of these appearing conspicuously in vertical sections as so many large rounded apertures. The range of *Stylodictyon*, so far as we know, does not extend beyond the Devonian. We append a short definition of *S. retiforme*, the only other type of this group with which we are acquainted.

STYLODICTYON RETIFORME, Nich. & Murie.

Skeleton massive, composed of vertical columns, surrounded concentrically by laminæ, the interlaminar spaces being crossed by delicate vertical or "radial" pillars. The columns themselves are made up of reticulated calcareous tissue, sometimes with a central vacant space or canal; and their diameter (including that of the concentrically-disposed vesicular tissue round each) varies from one to two lines. They are placed about their own diameter apart; and the interspaces between them are filled with loosely reticulated tissue. No radiating water-canals are present.

This species was collected by Mr. George Jennings Hinde, who recognized its novelty, and kindly furnished us with specimens. It is at once distinguished from *S. columnare* by the reticulated nature of the columns which intersect the mass, and by the absence of radiating canals, as well as by other points which we need not notice here.

Form. & Loc.—Hamilton Formation, Rivière aux Sables, Ontario, rare. *Coll.* Hinde and Nicholson.

(*e*) STROMATOCERIUM, Hall (emended).
(Pal. N. Y. vol. i. p. 48.)

Skeleton ("sarcodeme") massive, composed of dense and thick calcareous horizontal and concentric laminæ, separated by very narrow and irregular interspaces. The horizontal laminæ are not continuous, but are irregularly disposed; there are no "radial pillars" crossing the interlaminar spaces; and the entire mass is perforated by vertical tubes, which have no walls, are much smaller than the tubes of *Caunopora*, and are placed at short but irregular distances apart. These tubes place the successive interlaminar spaces in communication; and though they often run through many interspaces successively, they cannot be said to be continuous from the top to the bottom of the mass. Surface unknown.

Type.—Stromatocerium canadense, Nich. & Murie.

As previously stated, we have restored Hall's genus *Stromatocerium* for the reception of a Stromatoporoid from the Trenton Limestone of Canada (Lower Silurian), which we have reason to think to be allied to Hall's *Stromatocerium rugosum*, or possibly even identical with it. The species just referred to, however, was very imperfectly defined; and the genus was not characterized in any recognizable manner. There is, however, no doubt that the form figured and described by Hall is a true Stromatoporoid; and as we know of no other members of this group at this horizon, we have thought it best to restore Hall's genus, rather than to create a new one, though our type is so clearly distinct from all the other Stromatoporoids that we should have been quite justified in giving it a fresh generic designation. As Hall's species, however, cannot be recognized, we shall provisionally describe our form under the name of *S. canadense*.

STROMATOCERIUM CANADENSE, Nich. & Murie.

Spec. char.—Skeleton having the form of large rounded or irregular masses, conspicuously composed of numerous dense concentric laminæ, about five of which (with the intervening interlaminar spaces) occupy one line. The interlaminar spaces are open, without radial pillars; and the mass is traversed by numerous discontinuous vertical canals, from $\frac{1}{50}$ to $\frac{1}{80}$ inch, or less, in diameter. Surface-characters unknown.

Form. & Loc.—Trenton Limestone (Lower Silurian), Lake Couchiching and Peterborough, Ontario. *Coll.* Nicholson.

(*f*) PACHYSTROMA, Nich. & Murie.

Skeleton massive, composed of numerous concentric calcareous laminæ of extraordinary thickness, which are either in contact with one another or are separated by narrow and irregular interspaces. When interlaminar spaces exist, they are open, and there are no "radial pillars." The great concentric laminæ are composed of dense and indefinitely, but very minutely, porous and reticulate calcareous tissue, having no regular arrangement, but perforated by numerous very minute, irregular, vertical vermiculate tubes, without distinct walls. Horizontal radiating groups of water-canals are present. Surface smooth.

Type.—Pachystroma antiqua, Nich. & Murie.

The type species of this singular genus is from the Upper Silurian (Niagara Limestone) of Canada; but we must also refer here the *P.* (*Syringostroma*) *densa*, Nich., of the Devonian of Ohio. In this latter form (Pal. Ohio, vol. ii. p. 251) the radiating

water-canals are of comparatively large size, and their apertures are conspicuously visible in vertical sections. We subjoin a brief diagnosis of the type species.

PACHYSTROMA ANTIQUA, Nich. & Murie.

Sarcodeme massive, subspherical, of thick concentric laminæ, which have the extraordinary thickness of from three quarters of a line to two lines. Interlaminar spaces wanting or irregular. Even when there are no interlaminar spaces, however, the separate laminæ are always marked by a distinct interval, which marks a stage of growth, and which if followed laterally is found to expand into irregular interspaces. Surface with delicate branching canals arranged in stellate systems. Internal structure of laminæ minutely porous and reticulate, especially towards their central parts, with delicate vertical tubes at intervals.

Form. & Loc.—Niagara Limestone, Thorold, Ontario. *Coll.* Nicholson.

(*g*) DICTYOSTROMA, Nich.
(Pal. Ohio, vol. ii. p. 254.)

Sarcodeme massive, composed of thick solid calcareous concentric laminæ, apparently traversed by horizontal canals, and separated by wide interlaminar spaces. Upper surfaces of the laminæ sending off strong calcareous processes, which represent the "radial pillars," but seem not to be directly connected with more than the lamina from which they spring.

Type.—*Dictyostroma undulata*, Nich. This form resembles *Stromatopora* proper in general structure, except that the laminæ and interlaminar spaces are of comparatively gigantic size. We have had no opportunity of examining its minute structure; and therefore the group cannot be properly characterized.

The type species of this group is from the Niagara formation (Upper Silurian) of Kentucky; and we know of no other form at present.

AFFINITIES AND SYSTEMATIC POSITION OF THE STROMATOPOROIDS.

That the fossils under the so-called *Stromatopora* include a number of forms at first difficult to collate, has been admitted by most authorities who have investigated the group. As we have shown, certain specimens which, from their general aspect, the localities where obtained, and other reasons, must, for the present at least, be deemed Stromatoporoids, are nevertheless so aberrant, and sometimes so altered in condition and minute structure, as to leave a loop-hole of doubt concerning their nature. Dismissing

at this juncture such variations and gradations, the more typical forms at all events are indubitably marine organisms often associated with Coral formations, in the concretionary mass and débris of which occasionally shells, encrinites, and various other foreign bodies are mixed. Their main characteristics are:— Masses laminar, in thicker or thinner layers, concentrically arranged and mostly fastened to a foreign body; surface with or without elevations, and usually though not always exterior orifices of two kinds; in some instances channels perforate the substance; the latter composed of a series of laminæ so disposed as to enclose cellular interspaces, rectangular, retiform or otherwise; stellate surface-tracery and an epitheca are occasionally present.

In discussing the question as to the affinities and systematic position of the Stromatoporoids, probably the best course to pursue will be to review briefly the chief arguments for and against their allocation to the several zoological groups in which they have been placed by different observers—the groups in question being the Corals, the Hydrozoa, the Foraminifera, the Sponges, and the Polyzoa,—previous to which we will advert to certain marine Plants, viz. the Corallines.

1. *To Nullipores.*—Although so far as we are aware no one has suggested *Stromatopora* to have a vegetable alliance, nevertheless there is in some respects a wonderful resemblance to certain of the Nullipores.

Thus many of these Lithophytes or Stone Plants simulate the characters of *Stromatopora*, inasmuch as they are calcareous in substance, spread or insinuate themselves in thin layers parasitically between corals and other foreign bodies, occasionally form denser incrusting masses, have a nodular and granulated surface, invest and cover objects in successive layers, and in their minute structure present extreme regularity, with a tendency to quadrangular cell-construction. While these remarks apply in a general way, it by no means follows that the fossil *Stromatoporæ* belong to the group in question; on the contrary the bulk of evidence goes to support the view that their skeleton is the product of animal organization.

Setting aside the leafy jointed Corallines as at a glance outwardly distinctive in form, habit, &c., we were fortunate in obtaining some large pieces of Nullipores from South Africa (species undetermined) for comparison. These Nullipores were, roughly speaking, of two kinds, viz. a few large crustaceous forms, and others of a short, compact, branching, or interwoven sort.

The former, crust-like expansions, had an undulating mamillated contour, and in part a granular superficies. The nodular and nipple-shaped elevations also sparsely showed apical perforations; and here and there the broken surface demonstrated a tendency to scaly layers. Thus, what with the dirty brownish-white colour of the specimens, and other visual characters, there was indeed great likeness to some specimens of *Stromatopora.* The other, densely interwoven, branching Nullipores in their general configuration and chalky colour more markedly differed from the ordinary Stromatoporoid appearance.

In both series of Nullipores, however, in this mere casual outward examination, it was interesting to note how in the weathered areas and undulating exposed layers the calcareous films and subjacent often reticular substance evinced a similar disposition to put on the Stromatoporoid facies. Another feature more manifest in some than in others of the specimens was the presence of larger tortuous and other perforations of a boring parasite, besides undoubted tortuous *Serpula*-tubes, and foreign substances intermixed in the crevices. In none of these specimens did any of the fresh or weathered sections offer the special feature of *Stromatopora*, viz. distinctly perceptible interlaminar spaces and vertical radial pillars; though, as aforesaid, in weathered superficial layers minutely cribriform structure occasionally prevailed. Instead, throughout the mass as a rule the dense chalky consistence appeared to the eye or through the hand-lens. Stellæ or radiate water-canals are entirely absent both superficially and deeply.

As regards their intimate and minute structure, microscopical sections, made in various directions and from each and all of the specimens, only confirmed what is already well known concerning the histology of the Corallinaceæ. Their distinctive vegetable cells, far more minute than any of the so-called sarcode-chambers of the Stromatoporæ, perfectly agreed in every detail with those of the Corallineæ and Nulliporæ of our own coasts—to wit, such forms as *Corallina officinalis*, *C. incrassata*, *Melobesia polymorpha*, and *M. pustulata*, &c.

Thus, taken as a whole, the Nullipores do not possess Stromatoporoid essentials; and what resemblances exist between them are rather a combination of superficial characters than those of close or true affinity. The study and comparison of these South-African Nullipores, among other things, carries with it this useful lesson—that these calcareous bodies are subject to extraneous in-

fluences for the production of most if not all of their canalicular, and what may be termed poriferous aspects. The similitude to what is extant in certain of the Stromatoporoids in this connexion suggests caution in the interpretation of these structures in the latter.

2. *To Foraminifera.*—We may next briefly consider the chief facts bearing upon the relationship of the Stromatoporoids to the Foraminifera—a relationship which has been frequently suggested, and which has been more especially insisted on by Principal Dawson (' Dawn of Life,' p. 156 *et seq.*)

As this distinguished observer, we believe, is about to publish in full the results of his investigations into this subject, we shall merely make a few brief remarks on the question, the more so as we have already (see pp. 193 & 195) referred to Dr. Dawson's views so far as published. If we compare such a Stromatoporoid as those which we have described under the name of *Clathrodictyon* with such a Foraminifer as *Tinoporus*, there is no doubt as to the striking general similarity in minute structure; but this similarity becomes much reduced if we take for the purpose of this comparison the more regular and typical forms constituting *Stromatopora* proper. In thin sections of *Clathrodictyon cellulosum*, Nich. & Murie, we have thought that we have been able to make out minute microscopic tubuli, placed side by side, and uniting neighbouring compartments of the fossil directly with one another. If we could have established this point (and we have seen similar appearances in some other forms), then we might have instituted a direct and close comparison between *Clathrodictyon* and *Tinoporus*. Unfortunately, we have not been able to satisfy ourselves thoroughly that these apparent tubuli have any actual existence even in the forms above alluded to; whilst in the great majority of forms we have failed to detect any traces of similar structures. So far as our present observations go, therefore, we are unable to assert positively that the skeleton of the Stromatoporoids is perforated by any system of *microscopic tubuli*, similar to the tubuli found in the test of the Perforate Foraminifera; and we do not, therefore, feel ourselves justified in considering that there is any direct affinity subsisting between the two groups of organisms.

Exception, however, may be made to *Loftusia* and *Parkeria*. Amongst the undoubted fossil Foraminifera, the nearest ally of the Stromatoporoids is probably to be found in the gigantic arenaceous Foraminifers of the Greensand described by Dr. Carpenter

under the name of *Parkeria*, in an exhaustive and fully illustrated monograph (Phil. Trans. vol. clix. p. 721). Dr. Carpenter suggested to us in our present inquiry that we should find *Parkeria* to be related to the Stromatoporoids; and he kindly placed at our disposal a number of his microscopic preparations of the former. We have also carefully examined specimens of *Parkeria* by means of sections prepared by ourselves. *Parkeria*, as is well known, occurs in the form of globular bodies from about half an inch up to two inches or more in diameter. When these spheres are laid open, they are seen to be "formed of a series of concentric *lamellæ* of 'labyrinthic structure,' partially separated by concentrically disposed *interspaces*, but connected at intervals by 'radial processes,' which consist of large tubes that are surrounded (in all except the five or six innermost layers) by labyrinthic structure resembling that of the concentric lamellæ." The entire skeleton is made up of minute sand-grains and granules of phosphate of lime cemented together by a cement of carbonate of lime. In the fact that both *Parkeria* and the typical Stromatoporoids are composed of concentric laminæ, with interlaminar spaces and radial pillars, there is a striking resemblance established, enough to warrant the supposition that both might belong to the same systematic group. The *general* resemblance of structure thus indicated is even further increased when we compare with non-infiltrated specimens of *Parkeria* the decalcified casts in silica of the sarcode-chambers of a typical Stromatoporoid. We have, however, satisfied ourselves that no real relationship of affinity exists between *Parkeria* and *Stromatopora*; and the principal grounds upon which this conclusion is based are the following:—

(*a*) *Parkeria* possesses a skeleton essentially identical with that of the "arenaceous" Foraminifera generally, consisting, namely, of distinct grains of sand and phosphate of lime cemented together. *Stromatopora* and its allies, on the other hand, possess a *calcareous* skeleton, as we have formerly shown; and in no case can it be shown to be composed of definite and distinct *grains* of any mineral substance.

(*b*) All the parts of the skeleton of *Parkeria* have that complex construction out of minute irregular chambers, to which Dr. Carpenter applied the epithet "labyrinthic." On the other hand, the concentric laminæ and radial pillars of the Stromatoporoids do not exhibit any labyrinthic structure, though occasion-

ally porous. Even the huge lamellæ of *Pachystroma*, each of which probably represents several amalgamated lamellæ with their intervening interspaces in the ordinary Stromatoporoids, cannot be properly said to be "labyrinthic."

(*c*) The "radial" pillars of *Parkeria* are perforated by large canals. This is not the case, as a rule at any rate, with the Stromatoporoids, whilst there are forms amongst the latter in which the radial pillars are entirely wanting.

(*d*) In their general form and habit, the Stromatoporoids differ widely from *Parkeria*, the latter being free, whilst the former were attached to foreign bodies and sometimes incrusting or parasitic.

(*e*) Nothing comparable with the nucleus of *Parkeria** can be detected in any Stromatoporoid.

3. *To Sponges.*—According to Von Rosen the fossil form *Sparsispongia*, D'Orb., is really referable to the Stromatoporoids. If such is proved to be the case, it would seem not unlikely that the secondary genus *Stellispongia*, D'Orb., may really belong to the same group. But as we have had no opportunity of examining specimens of either of the above minutely and critically, for the time being we must leave the question open. The same may be said of certain other forms—to wit, *Spongia stellata*, Lamx., and specimens designated in our museums *Sphærospongia*.

It certainly is to the Sponges, more frequently than to any other group, that the Stromatoporoids have been referred by previous observers, including one of the present writers; and they have been placed, collectively or as regards individual form, in the groups of the Horny, the Siliceous, and the Calcareous sponges. On the whole subject of the relationship between the Stromatoporoids and the Sponges, we shall content ourselves with adducing the following considerations:—

First, the reference of the Stromatoporoids to the *Horny* Sponges, chiefly supported by the authority of Von Rosen, we believe to be entirely inadmissible; and, without entering into the question in detail, we may simply state that this conclusion was essentially based on the assumed fact that the Siliceous Sponges of the Chalk, since undoubtedly proved to possess a

* Our friend Dr. John Millar has enabled us to examine a series of most excellent specimens illustrating the structure of *Loftusia* and *Parkeria*. Two distinctive kinds of *Parkeria*, both in considerable abundance, have been got by him from the Cambridge beds. He is inclined to regard *Parkeria* as evincing affinities with the Polyzoa rather than strictly with the Foraminifera; but as his researches are still in progress we must defer further notice.

flinty skeleton, were really horny. Nor have our own researches upon the minute structure of the Stromatoporoids at all served to corroborate Von Rosen's view—that these organisms are composed of any thing to which the name of "*fibres*" could be properly applied.

Secondly, the principal observer who of late years has taken the view that the Stromatoporoids are Siliceous Sponges is Mr. Sollas (Ann. & Mag. Nat. Hist. ser. 4, vol. xix. p. 23), who places *Stromatopora concentrica* among the *Vitreohexactinellidæ*. Mr. Sollas, however, has subsequently (Quart. Journ. Geol. Soc. vol. xxxiii. p. 824) stated that he only believes some of the Stromatoporoids to be of this nature, and that others fall into different groups. As Mr. Sollas has not yet published any of the evidence upon which his views are based, it is, of course, impossible for us to express any opinion in the matter. Two observations only appear to be justifiable:—in the first place, that much will depend upon the question whether the form which Mr. Sollas calls *S. concentrica* (and which, if it be the *S. concentrica* of Goldfuss, is really identical with *S. polymorpha*, Goldf.) be truly referable to *Stromatopora* itself; and, secondly, that all the evidence derivable from the very extensive series of forms which have passed under our hands is, as we have previously stated at greater length, to our minds absolutely conclusive as to the original calcareous constitution of the Stromatoporoids. We should add, however, that we have not had the opportunity of examining personally the original types of *Stromatopora concentrica*, Goldf. (=*S. polymorpha*, Goldfuss), and have only had the opportunity of studying it by means of the excellent figures and descriptions of Von Rosen and Goldfuss. It is *possible*, therefore, that *this* form, the type of *Stromatopora* itself, will prove to be a Hexactinellid Sponge. In that case, however, we should simply have to withdraw all the forms which we have been considering in this memoir under the name of "Stromatoporoids," from any association with *S. polymorpha*, Goldf.; for we are quite satisfied that, whatever the true nature of *these* may be, they are not *Hexactinellidæ* *.

* Since our MS. has been lying in the printers' hands, one of us (H. A. Nicholson) has visited the Eifel, and has both collected a large series of Stromatoporoids from this classical district and examined those in the Bonn Museum. The result of this has been to satisfy us that the Stromatoporoids of the "Eifler-Kalk" are in no respect fundamentally different from those of the Devonian of Devonshire and North America. Further remarks on this head must be left to another opportunity.

In the third place, there remain for us to consider the possible relations between the Stromatoporoids and the Calcispongiæ. In this connexion we may first note the remarkable resemblances between the Sponges and the Stromatoporoids as regards their general form, their ordinary modes of growth (as evinced by some forms, though not all), and the principal characters presented to the unassisted eye by the free surfaces of each. We may next note the resemblance between these two groups, constituted by the presence in many Stromatoporoids (and perhaps in all) of two sets of apertures in the superficial layer, and two sets of canals perforating the skeleton. When we add that the apertures of the larger canals in some forms are placed at the summit of conical eminences, and that they may be disposed with some regularity, we have said enough to show how striking is the general resemblance between these two sets of openings in the Stromatoporoids and the "pores" and "oscula" of the Sponges. On the other hand, to resemblances like the above, which have so strongly impressed many observers, we have to oppose some serious and important points of dissimilarity. By far the most important of these is to be found in the nature of the skeleton. In all the known Calcispongiæ, the skeleton consists of free *spicules*, which are never amalgamated or fused with one another, and which, therefore, never form a continuous framework, however densely they may be packed together. In no Stromatoporoid, however, have free calcareous spicules ever been detected by any observer; and the skeleton is undoubtedly a more or less continuous one. If, therefore, we were to accept the view that the Stromatoporoidea were really referable to the Calcareous Sponges, we should have to assume that they constitute a special, peculiar group, bearing a relation to the typical Calcispongiæ somewhat similar to that which the Lithistidæ or Hexactinellidæ of the present day bear to those Siliceous Sponges in which the spicules are not united or soldered together (Sarcohexactinellida of Carter, the Lyssakina of Zittel). Nor can any serious *à priori* objection be brought against this view, since there is no fundamental reason why there should not be a group of Calcispongiæ with free spicules, and another group of the same with a vermiculate or reticulate continuous skeleton, just as we know that in nature there are found parallel groups amongst the Siliceous Sponges.

But withal there is still the further trenchant difficulty to be

surmounted—viz., that to substantiate the latter view it is necessary to assume as a fact a form of Sponge to the existence of which living representatives do not yield evidence of an unquestionable kind. This doubtless weakens the argument very considerably, however much the construction of the *Stromatoporæ* is spongiose in character. Nevertheless difficulties of a kindred nature, and quite as insurmountable, are to be met with, to whatever living group they may be compared.

4. *To Corals &c.*—The Stromatoporoids have been regarded by various observers as referable to the Actinozoa; and they have been placed, collectively or severally, amongst the Tabulate Corals, the Alcyonaria, and the Perforate Corals. As to their relationship with the Tabulate Corals (such as *Fistulipora*), or with the Alcyonarians (such as *Tubipora*), it may be at once stated that their minute structure, as displayed by means of thin sections, is conclusive against their reference to either of these groups, and shows, indeed, that their true nature is entirely different. For the view that they belong to the *Zoantharia perforata* more may be said. There is undoubtedly a close general resemblance between some of the Stromatoporoids, such as *S. discoidea*, Lonsd., and *S. granulata*, Nich., and some of the Perforate Corals, such as *Psammocora* and *Montipora* and other members of the Poritidæ—this resemblance depending partly upon the general similarity of the reticulate calcareous skeleton of both, and partly upon the likeness of the water-canals of the former to the corallites of the latter. When closely examined, however, this likeness is seen to be clearly superficial, and not fundamental. The minute structure of the general skeleton of the Stromatoporoids differs materially from that of the Perforate Corals in its arrangement; while the stellate systems of water-canals in the former, which simulate corallites, are really of a totally different nature, and are, under any circumstances, totally wanting in many Stromatoporoids. We may, therefore, unhesitatingly dismiss the view that the Stromatoporoids are to be referred to the Corals properly so-called.

Lastly, we may compare the Stromatoporoids, briefly, with the Carboniferous fossils which constitute the genus *Palæacis*, Haime, which have recently been carefully examined by one of us along with Mr. R. Etheridge, jun., F.G.S. The species of *Palæacis* are either free or attached to foreign bodies; and they differ from all the Stromatoporoids in the conspicuous presence of a variable

number of deep cups, which (on the view that *Palæacis* is a Coral) have been generally regarded as "calices." In their internal structure all the specimens of *Palæacis* are shown by microscopic examination to be composed of a reticulated calcareous tissue, which presents a close general resemblance to that of certain of the Stromatoporoids, while the surface is covered with tubercles and vermiculate ridges very similar to those exhibited by such forms as *Stromatopora tuberculata*, Nich., *S. discoidea*, Lonsd., &c. On the other hand, the reticulated tissue of *Palæacis* is not in any way divisible into concentric and radial elements, but is invariably irregularly and indefinitely trabecular, and the entire substance of the skeleton appears to be more or less conspicuously traversed by minute branching microscopic tubuli. There would not appear, therefore, to be any very close relationship between *Palæacis* and *Stromatopora*.

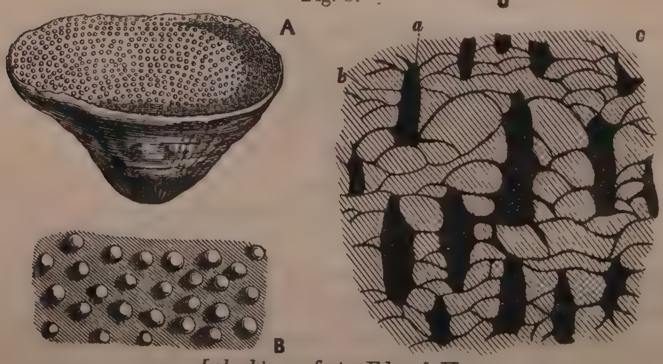
5. *To Hydrozoa.*—With regard to the reference of the Stromatoporoids to the Hydrozoa, we have to consider on the one hand their relationships to forms like *Millepora*, and on the other hand their affinities with *Hydractinia*. The likeness of certain of the Stromatoporoids to *Millepora* is very striking, but cannot be said to be sustained by a close examination, the arguments on this head being very much the same as those above referred to in connexion with the "Madreporaria perforata." Though *generally* like one another, no Stromatoporoid can be shown to consist of two definite systems of larger and smaller tubes, both divided by tabulæ; and none can be shown to possess a definite system of tubular cavities which can be supposed to have been tenanted by zooids, while many are destitute of even a semblance of structures of this nature. The only Stromatoporoids which would afford a reasonable basis for a comparison with *Millepora*, or with any of the so-called "Tabulate Corals," are those which form the genus *Caunopora*. If the structure of these has been rightly interpreted by us, and if the large vertical tubes of *Caunopora* really belong to the organism of which they seem to form a part, then we certainly have here a Stromatoporoid which may very fairly be compared with *Millepora*, or, indeed, with any of the so-called "Tabulate Corals." *Caunopora*, however, if its structure be rightly interpreted, is an aberrant form, and it cannot by itself decide the systematic position of the Stromatoporoids generally.

In 1876, Dr. Gustav Lindström (Ann. & Mag. Nat. Hist. ser. 4, vol. xviii. p. 4), in a paper on the "Anthozoa Tabulata," pointed out that the well-known Silurian fossil referred by Milne-Edwards

and Haime to the Tabulate Corals, under the name of *Labechia*, was rather related to the *Hydrozoa*. "In its earliest stages of growth, this fossil consists of a very thin circular disk, with concentric lines of growth beneath, and having the superior surface studded with blunt spines, which radiate from the centre, and also coalesce and form continuous ridges. In this state it reminds one of nothing more than the sclerobasis of the Hydrozoan genus *Hydractinia*; and the only difference seems to be that *Labechia* is entirely calcareous, whilst *Hydractinia* is corneous. During the course of growth, the primitive disk of *Labechia* is increased in thickness by the addition of successive thin strata, which closely conform to the subjacent fundamental crust, being elevated where the spines are situated. As these successive layers leave a small space between them, and are in themselves very thin, they give rise to a false appearance of tabulæ." (Lindström, *loc. cit.*) Dr. Lindström further points out that there are points of resemblance between *Labechia* and the Stromatoporoids which have been generally grouped together under the name of *Cœnostroma*; and he therefore throws out the suggestion that the latter may possibly have to be eliminated from the group of the Corals to which he thought them to belong.

Having carefully examined specimens of *Labechia*, both macroscopically and microscopically, we can entirely confirm Dr. Lindström's general description of the genus; and we altogether agree with him, that it certainly can not be referred to the Corals. Thin vertical sections (fig. 5, C) show that the skeleton is com-

Fig. 5.



Labechia conferta, Edw. & H.

A. A small specimen, of the natural size. B. A piece of the upper surface of the same, enlarged. C. Portion of a vertical section under a low microscopic power: *a*, the calcareous columns, represented as opaque; *b*, the vesicular tabulæ; *c*, calcite filling the lenticular vesicles.

posed of a series of short, discontinuous, fusiform, calcareous columns (*a*), which are about half a line in width, and are placed about half a line to a line apart. The spaces between these columns are occupied by curved calcareous lamellæ (*b*), which form a series of comparatively large lenticular vesicles (*c*). The upper surface is formed by the upper surfaces of these calcareous lamellæ, and by the prominently protruded free ends of the columns. The columns are wholly solid and imperforate, as are the lamellæ of the vesicular tissue. The vesicles of the latter, therefore, appear to be entirely destitute of any intercommunication, and we have failed to detect any openings or pores of any kind on the upper surface. The lower surface is likewise imperforate, and is covered by a concentrically striated calcareous membrane or "epitheca," which envelops all the inferior surface, except the comparatively small peduncle by which the colony is attached to foreign bodies.

That there is some resemblance between *Labechia* and some of the coarsely tuberculated species of *Stromatopora* is undeniable; but it appears to us to be a superficial likeness, and we are not prepared at present to offer a decided opinion as to the affinities of the former. That *Labechia* has also a *general* resemblance to the crusts of *Hydractinia* is also undeniable, especially now that Mr. Carter has described calcareous species of the latter genus (Ann. & Mag. Nat. Hist. ser. 4, vol. xix. 1877); but there are the following very important points to notice in this connexion. The colonies of *Labechia* are not *incrusting*, as are those of *Hydractinia*, but form expansions, resembling those of many corals, attached to a foreign body at one point, but having the greater portion of the inferior surface free and covered by a concentrically striated "epitheca." The columns of *Labechia* are invariably solid throughout, whereas the spines of *Hydractinia* are more or less reticulated basally, or traversed by a central canal. Lastly, the upper surface of *Labechia* has not yet been shown to present any apertures or crypts, such as may be supposed to have given exit to *zooids* of any description.

Recently Mr. Carter has thrown out the suggestion, and has strongly supported the view, that *Stromatopora* is truly very closely related to *Hydractinia*. We have very carefully studied the two memoirs which Mr. Carter has published bearing upon this subject (see Ann. & Mag. Nat. Hist. ser. 4, vol. xix. p. 44, 1877, and *ibid.* ser. 4, vol. xi. p. 1, 1873), and we have also spe-

cially examined our numerous thin sections of various Stromatoporoids, with a view of collecting all the evidence which these might offer in support or disproof of this view. Not having had the opportunity of thoroughly examining any *calcareous* species of *Hydractinia*, we should feel it presumptuous to express a final opinion on this question; but we submit the following considerations as, in our judgment, warranting the belief that at present there is insufficient evidence to connect the Stromatoporoids with *Hydractinia*, though such a connexion may subsequently be established.

First. As to general form and habit, few Stromatoporoids could be properly said to be *incrusting*, as compared with a *Hydractinia*, since they very rarely form *thin* crusts attached by the whole of the lower surface to foreign bodies. On the contrary, they either form massive aggregates, like those of many Corals, which may be attached by one point to a foreign body, or may have grown round such as a nucleus; or, in many cases, they form extended expansions, quite like those of many Corals (such as species of *Fistulipora*, *Favosites*, &c.), attached by a comparatively limited point to some foreign object, and having almost the whole of the lower surface *free* and covered with a well-developed calcareous striated membrane or "epitheca."

Secondly. The resemblance between the minute structure of the crust of *Hydractinia* and that of the typical Stromatoporoids is, in our opinion, a purely general one, and is not nearly so close as the resemblance between the Stromatoporoids and certain of the perforate Corals or such Hydrozoans as *Millepora*. This is particularly well seen by a comparison of magnified thin vertical sections of examples of these different groups.

Thirdly. The resemblance of the tuberculated superficial layer of certain Stromatoporoids to the upper surface of the crust of *Hydractinia* is also, in our opinion, a superficial one; whilst many Stromatoporoids, precisely agreeing with the former in minute structure and in the general arrangement of their parts, have perfectly smooth surfaces.

Fourthly. Many Stromatoporoids show very unmistakably two sets of apertures, one large and the other small, upon the surface, the large openings being often placed upon the end of rounded or conical eminences, and being often extremely regular in their arrangement. These phenomena cannot be paralleled by any thing exhibited by *Hydractinia*, so far as we are aware.

Fifthly. The stellate systems of water-canals, so commonly, though not universally, present in the Stromatoporoids, are apparently believed by Mr. Carter to correspond with the branched grooves and cœnosarcal stolon-like tubulation which he has described as characterizing the surfaces of the layers of the crusts of *Hydractinia*. We are unable to accept this view, upon the ground that the radiating water-canals of the Stromatoporoids, though sometimes superficial, especially where arranged round a superficial eminence, more commonly pass obliquely through the successive laminæ and interlaminar spaces, perforating these, as several of our preparations show, one after the other, and not lying in the plane of any particular lamina.

Sixthly. One of the Stromatoporoids which Mr. Carter has examined (Ann. & Mag. Nat. Hist. ser. 4, vol. xix. pl. viii. figs. 22, 23), and from which he has drawn important conclusions supporting his views, appears to us to be a member of the aberrant and still imperfectly understood genus *Caunopora**, or, if not so, to be a specimen in which a colony of *Stromatopora* has grown round and enveloped a colony of the coral *Syringopora*.

6. *To Polyzoa*.—We have already intimated (*antea*, p. 190) that the idea of the affiliation of *Stromatopora* to the Polyzoa is not new, since the two Sandbergers and Ferd. Roemer (1850–1856), for the reasons heretofore given, held this view. Apart from their interpretation of the structural resemblances, we have brought to bear examinations and comparisons on our own behalf. Among an extensive series of recent and fossil Polyzoan forms investigated by us with reference to the question at issue, we have been particularly struck by a good example of *Eschara nobilis*, Michelin. This specimen, from the Upper Greensand, was an ovoid mass several inches in diameter, externally irregular, roughened, and scaly, but with no elevations, perforations, or otherwise special outward resemblance to the Stromatoporoids. A vertical section through its middle displayed a small foreign body as a nucleus, around which, like the coats of an onion, in regular successive layers, about six to a line in depth, the tiers of zooidal cells were ranged. Thus this vertical section—what with the walls of the zoœcia so built up as to represent horizontal or concentric laminæ and vertical or radial pillars, the cells themselves resem-

* Quite recently, while this is passing through the press, Mr. Carter himself announces his mistake and admits his supposed *Stromatopora* to have been *Caunopora placenta* (Ann. & Mag. Nat. Hist., July 1878).

bling interlaminar spaces, and, moreover, the fossilized calcareous nature of the whole—undoubtedly simulated in a forcible manner the characters of *Stromatopora* in vertical section. This will readily be allowed if fig. 13, Pl. IV., be compared with fig. 3, Pl. I. If, again, the surface of one of the layers of *Eschara nobilis*, fig. 12, Pl. IV., be compared with the surface of the concentric laminæ of *Stromatopora tuberculata*, fig. 2, Pl. I., less likeness is discernible, though the weathered protruding pillars and pseudo-orifices of the latter may at first sight be taken for the cell-orifices of the former.

Closer inspection, however, does not bear out such apparent agreement; for the regularity in shape and position of the cells and orifices of the polyzoarium of this species of *Eschara* (*Hemeschara*, Busk), avicularia, and other secondary features are completely at variance with the structural surface-peculiarities of *S. tuberculata* and all other species of the genus. But even the general similarity of facies of vertical sections between the two forms in question diminishes in proportion as detailed and microscopic investigation is pursued; and from such Stromatoporoid genera as *Caunopora*, *Stylodictyon*, &c., the polyzoarium of *Eschara* departs still further. Another genus of the family of Escharidæ, namely *Retepora*, occasionally, to a certain extent, simulates the minute vesicular structure of *Clathrodictyon*; but the general fenestrated foliaceous nature of its polyzoarium, presence of avicularia, marginal spines, ovicells, &c., sufficiently distinguish Polyzooid from Stromatoporoid organization. Among the family of Celleporidæ again, in certain of its forms, sufficient likeness can be traced to justify a comparison with *Clathrodictyon*, and partially, it may be, with *Stylodictyon*. Here, in the genus *Cellepora*, the erect dichotomously branched species must be excluded, and only the globose spreading adnate forms taken into account. Even these latter seldom, if ever, assume the outward form of the Stromatoporoids, not excepting the recent *Cellepora mammillata*, with its incrusting polyzoarium and surface-projections. Their vertical or horizontal section in mass, though, does assume something of the cellulo-vesicular character of similar sections of *Clathrodictyon*. The heaping together and vertical inclination of the cells of the polyzoarium of *Cellepora* is, however, only a deceptive likeness; for even in the fossil species of the genus the punctured or sculptured character of the cell-walls, the presence of rostra, avicularia, ovicells, and often denticles, sinuses, or spines,

each, or all together, forbid the idea of identity with *Clathrodictyon* or its Stromatoporous allies. We have more especially directed attention to the above families of Polyzoa as those possessing the greatest likeness to the series of fossil forms at issue; for it is chiefly in the suborder Cheilostomata that the polyzoarium manifests skeletal likeness to most of the Stromatoporoids. Nevertheless we would remark that among the suborder Cyclostomata the genera *Heteropora*, De Blainville, and *Heteroporella*, Busk*, possess more than a usual amount of interest. Both have a surface furnished with openings of two kinds, viz. cell-orifices and tubes, the latter penetrating the polyzoarium vertically, and occasionally containing a kind of imperfect septa. These structural peculiarities are suggestive of *Caunopora*. Still they are deceptive resemblances; for in the Cyclostomata in question the canalicular cells or zoœcia run in close apposition alongside the tubular passages and in the same vertical direction, whereas in *Caunopora* the thick-walled tubes run diagonally to the laminæ and sarcode-chambers, besides others points of dissimilarity. In some species of *Heteropora* Mr. Busk mentions the presence of a superficial stellate appearance in connexion with the interstitial orifices; but what relation these may bear to the oblique radiating water-canals of the Stromatoporoids, we have not had the opportunity of accurately determining. It is sufficient for our purpose to show that, besides outward aspects, in other more important respects the diversity of structure establishes distinction between the Cyclostomatous Polyzoa and Stromatopora. Furthermore, as a whole, in zoœcia, oœcia, vibracula, avicularia, tubules, porous walls, and a variety of other minor particulars, the Polyzoa do not accord with any of the types of the Stromatoporoids.

Summary and Conclusion.

In this communication we have first given an epitome of the very diverse views held regarding *Stromatopora* up to the present time. We then treat of its fossil state, and show that, although the remains have been preserved in several mineral conditions, nevertheless the skeletal organization originally has been solely of a calcareous nature. We further contribute data bearing on the structural peculiarities, not only exteriorly and generally, but as elucidated by microscopic research. It results that neither are

* 'A Monograph of the Fossil Polyzoa of the Crag,' pp. 121 & 126.

the horizontal laminæ always porous nor the vertical pillars usually tubular, as some have asserted. In one peculiar aberrant form, *Caunopora*, there are, in addition, large, thick-walled tubes penetrating the mass vertically, and undoubtedly belonging to the organism itself. In some forms, notably the genus *Stromatocerium*, there is a system of more or less perpendicular canals and lacunæ without walls; in others there is a paucity or even absence of such, though, in most, smaller and larger apertures open superficially. A further system of stellate obliquely disposed canals exists, in many forms, both deeply and on the surface of the outer layers. While the typical *Stromatoporæ* are characterized by horizontal laminæ, supported by short upright pillars enclosing cuboid chambers or cells, some take on a vesicular character (*Clathrodictyon*), and others (*Pachystroma*) are destitute of pillars. Still other examples, essentially Stromatoporoid in aspect &c., assume a more indefinite minute structure, with a tendency to a reticulate or trabecular formation. In certain forms (notably *Stylodictyon*) a columnar character obtains, the chambers showing a concentric arrangement round a dense but reticulate centre. Thus by their intimate structural peculiarities we attempt a tentative classification, wherein we can distinguish at least seven types of construction which we rank provisionally as genera, and we describe *en passant* a few new and remarkable species.

In discussing the affinities of *Stromatopora* and its allies, we bring forward such evidence and argument as we believe is sufficient to warrant our excluding them in the meanwhile from alliance with the Nullipores, the Foraminifera, the Hexactinellid Sponges, the Polyzoa, the Corals, and certain fossil forms of uncertain affinities. As respects their Hydrozoal connexion we express ourselves with greater reticence, inasmuch as both in *Hydractinia* and *Millepora* not only are there certain superficial resemblances of considerable importance, but through the curious divergent form *Caunopora* structural peculiarities present themselves which possibly point to Hydrozoal relationships. Moreover, Mr. Carter's late very shrewd observations among the chitinous and calcareous *Hydractiniæ* necessarily render the subject at issue open to further research before the decided negative can be affirmed. Mr. Moseley's * able investigations on the *Hydrocorallinæ* during the 'Challenger' Expedition, while they yield valuable

* Philos. Trans. 1876, vol. clxvi. pp. 91–129, pls. 8 & 9.

hints, do not yet afford all that is desirable to unravel the knotty point. It is possible, though, that his future investigations of the ample material brought home may supply facts bearing more directly on the skeletal structure of the fossil Stromatoporoids. Lastly, respecting Sponge alliance, we are beset by obstacles, for neither do the Horny, Siliceous, nor Calcareous divisions, recent or fossil, so far as present knowledge extends, supply us with stable data whereon to assert identity. By reason of the nature of the skeletal basis, the two former groups are necessarily excluded; while total absence of spicules in the *Stromatoporæ*, as widely understood, renders it impossible to class them unconditionally with the Calcareous order of the Sponges. But seeing that Hydrozoa lconstruction, with its tubular zooidal cavities, tabulæ, &c., has not been shown to exist in the typical forms of the Stromatoporoids, and that neither in *Millepora* nor *Hydractinia* &c., so far as we are aware, does such a system of intercommunicating passages and occasionally lacunæ without walls obtain, as exemplified in *Stromatocerium* &c., we are constrained to adopt the parallel of the Siliceous sponges with fused and adnate spicules, and assume the existence in times past of a Calcareous group of the class Spongida with a continuous skeleton composed of non-spicular granular calcareous matter. We are, however, by no means prejudiced, but hold ourselves open to conviction; for if hereafter it be demonstrated that the canal-systems &c. of the *Stromatoporæ* are not normal productions, as we at present believe them to be beyond any reasonable doubt, but "branching canals bored by some low vegetable organism," as Moseley (*l. c.* p. 116) avers is the case in *Millepora* and *Pocillopora* &c., and, furthermore, that other structural Stromatoporoid peculiarities are present in undoubted members of the Hydrozoa, then we shall be willing to admit their alliance with the latter, though certainly they are aberrant types. With our present imperfect knowledge, and taking into account all the data for and against, we must at present regard them as a group *per se*, or, as we think justifiable on the positive and negative evidence, a new section of the Calcareous Sponges, for which we propose the term STROMATOPOROIDEA.

DESCRIPTION OF THE PLATES.

PLATE I.

Fig. 1. *Stromatopora tuberculata*, Nich. A small portion from the Corniferous Limestone, Jarvis, Ontario, showing, above, the roughened nodular or

tuberculate and granular surface, and also below, in side view, the (weathered) series of undulating layers composing the thickness of the specimen. About the natural size.

Fig. 2. Another, smaller, piece of *Stromatopora tuberculata*, exhibiting the surface of the concentric lamina, its granular intermediate structure and protruding pillars with pseudo-orifices, × 3 diam. (from the Devonian measures, Canada), and in which the skeleton has been silicified and the filling up of the chambers calcareous.

Fig. 3. A vertically exposed fragment of *S. tuberculata*, preserved in the same way and decalcified by weathering. The chambers, horizontal laminæ or concentric layers, and the vertical or radial pillars stand out in relief. × 3 diam.

Fig. 4. The form usually known as *Stromatopora striatella*, D'Orb. A transparent vertical section of an example from the Wenlock, Upper Silurian, Gotland, Sweden. Seen under a 2-inch object-lens (= ×20 diam.), and, as in fig. 3, exhibiting the chambers, horizontal laminæ, and radial pillars.

Fig. 5. A partly tangential and transverse section of the same piece of *S. striatella*, ×20 diam., and in which the cut ends of the radial pillars are very manifest.

Fig. 6. Another, chiefly vertical, section, but from the same specimen of *S. stritella*, under a 1-inch objective, ×60 diam. The granular character of the horizontal laminæ and vertical pillars, and the occasional intercommunication of the chambers by imperfection of the septa, are markedly visible.

Fig. 7. An oblique or tangential section of the so-called *S. striatella*, also viewed with an inch objective (= ×50 diam.).

Fig. 8. *Stromatopora nodulata*, Nich. A transparent vertical section of a piece from the Corniferous Limestone, Ohio. Twice nat. size.

Fig. 9. A portion of the above specimen of *S. nodulata*, under a 2-inch object-lens (= × 20 diam.). In this figure the irregularity in size and shape of the sarcode-chambers and variability in thickness of the concentric laminæ and vertical pillars are noteworthy. The specimen itself shows, what is barely represented in the drawing on stone, that both laminæ and pillars, but especially the former, are remarkably granular in consistence, and in many instances a series of subsidiary thin layers compose each lamina, or give it a somewhat reticulate porous appearance.

Fig. 10. *Stromatopora mammillata*, Nich. A small portion of the surface of an extensive thin crust, exhibiting its conical elevations, a few of which appear perforated. On the undulating granular intervening spaces, rather indistinct however, are traces of stellæ or radiate water-canals. From the Corniferous Limestone of Port Colborne. Nat. size.

Fig. 11. *Stromatopora* (*Cœnostroma*?) *granulata*, Nich. Stellar grooves or radiate water-canals with surrounding miliary granulation on the weathered surface of a portion of an undulating crust. Nat. size.

Fig. 12. *S.* (*Cœnostroma*?) *granulata*. A vertical transparent section, ×6 diam. This irregular-looking crust had grown and pushed its way among some coral débris. Magnified more highly, portions of this specimen still

better manifest the tendency to thin secondary horizontal arching among the chambers and laminæ.

Fig. 13. Tangential section of *S. granulata*, a small area under a 4-inch object-lens (= × 10 diam.). The irregular shapes, sizes, and disposition of the cut ends of the main and subsidiary laminæ bear out what has been said of fig. 12. This and the two preceding objects are from specimens obtained in the Hamilton group, Ontario.

PLATE II.

Fig. 1. *Stromatopora ostiolata*, Nich. A vertical section of a segment of a hemispherical piece, × 6 diam.

Fig. 2. A tangential section of *S. ostiolata*; a limited area under a 2-inch object-lens (= × 20 diam.). This and fig. 1 are from the Guelph Limestones (Upper Silurian), Canada: they have been preserved in crystalline dolomite, and are both very imperfect in minute structure.

Fig. 3. *Cœnostroma discoideum*, Lonsdl.? An oblique transparent section under a 1-inch object-lens (= × 60 diam.). The slide was a poor one, by no means clear in outline. From the Wenlock Limestone, Gotland, Sweden; named by Lindström. It is uncertain if it be Lonsdale's *Heliolites? discoideus*; equally it is doubtfully a so-called *Cœnostroma* or true *Stromatopora*.

Fig. 4. *Caunopora planulata*, Phill., obtained from the Devonian, Babbicombe, Devonshire. A small segment of a partially vertical and oblique section, under a 4-inch objective (= × 10 diam.).

Fig. 5. A portion of the last vertical section (*C. planulata*) more highly magnified (viz. 2-inch objective, = × 20 diam.). Both show the calcareous thick-walled tubes partly lengthwise and cut across, and also the reticular concentric laminæ. Unfortunately none of the occasional interconnecting tubules have been shown in figs. 4 and 5.

Fig. 6. *Clathrodictyon cellulosum*, Nich. & Murie. Enlarged fragment, but natural appearance, of a weathered, opaque, vertical surface, showing sarcode-chambers &c., × 4 diam. The skeleton is here siliceous, and the calcareous filling of the chambers has been removed by the weathering process; the walls of the chambers everywhere exhibit quite a porous appeaarnce. Figs. 6 to 10 are from the Corniferous Limestone (Devonian), Canada.

Fig. 7. Natural casts in silica of the sarcode-chambers of *Clathrodictyon cellulosum*, × 4 diam. The calcareous skeleton has been removed by weathering; the surfaces of the interlaminar spaces are shown.

Fig. 8. A segment of a transparent vertical section of *C. cellulosum*, as seen magnified with a hand-lens (= × 2½ diam.).

Fig. 9. A portion of the same section of *C. cellulosum* under a 2-inch objective (= × 20 diam.). The conspicuous absence of radial pillars, other than as inflected cell-walls, and the occasional stretching of a thin partition obliquely across, may be noticed. (The artist has placed this figure so that the horizontal laminæ are in an upright position.)

Fig. 10. A tangential section of *C. cellulosum*, also under a 2-inch object-lens (= × 20 diam.).

Fig. 11. *Clathrodictyon vesiculosum*, Nich. & Murie. A vertical transparent

section, under a 1-inch objective (= ×60 diam.). The granular nature of the cell-walls is marked. Figs. 11–13 are from the Clinton formation (Upper Silurian), Ohio, and have been preserved in crystalline dolomite.

Fig. 12. A tangential section of *C. vesiculosum* under a 2-inch object-lens (= ×20 diam.).

Fig. 13. One of the stellate or radiate water-canals of *C. vesiculosum*, magnified with a pocket-lens (= ×4 diam.).

Fig. 14. *Stylodictyon retiforme*, Nich. & Murie. A few of the nipple-like elevations on the surface. About natural size.

Plate III.

Fig. 1. A portion of a vertical section of *Stylodictyon retiforme* as viewed under a hand-lens (= ×3 diam.). This, the preceding, and two succeeding preparations are from specimens collected in the Hamilton formation (Devonian), Canada.

Fig. 2. Part of the same vertical section of *S. retiforme* under a 4-inch objective (= ×10 diam.). In figs. 1 and 2, vertical, and fig. 3, transverse, section, the more dense but reticular nature of the vertical columns is specially marked; and in the first two the very characteristic wavy laminæ and unequally lengthened vertical or radial pillars at once call attention.

Fig. 3. A transverse or slightly oblique section of the area composing one of the distinguishing vertical columns of *S. retiforme*, under a 4-inch objective (= ×10 diam.).

Fig. 4. *Stylodictyon* (*Syringostroma*) *columnare*, Nich. A horizontal or transverse polished opaque section. Nat. size.

Fig. 5. A vertical polished section of the same piece of *S. columnare*, also of nat. size, the light-coloured columns in this and the last being readily appreciable to the naked eye. Figs. 4–8 are from the Corniferous strata (Devonian) of Ohio.

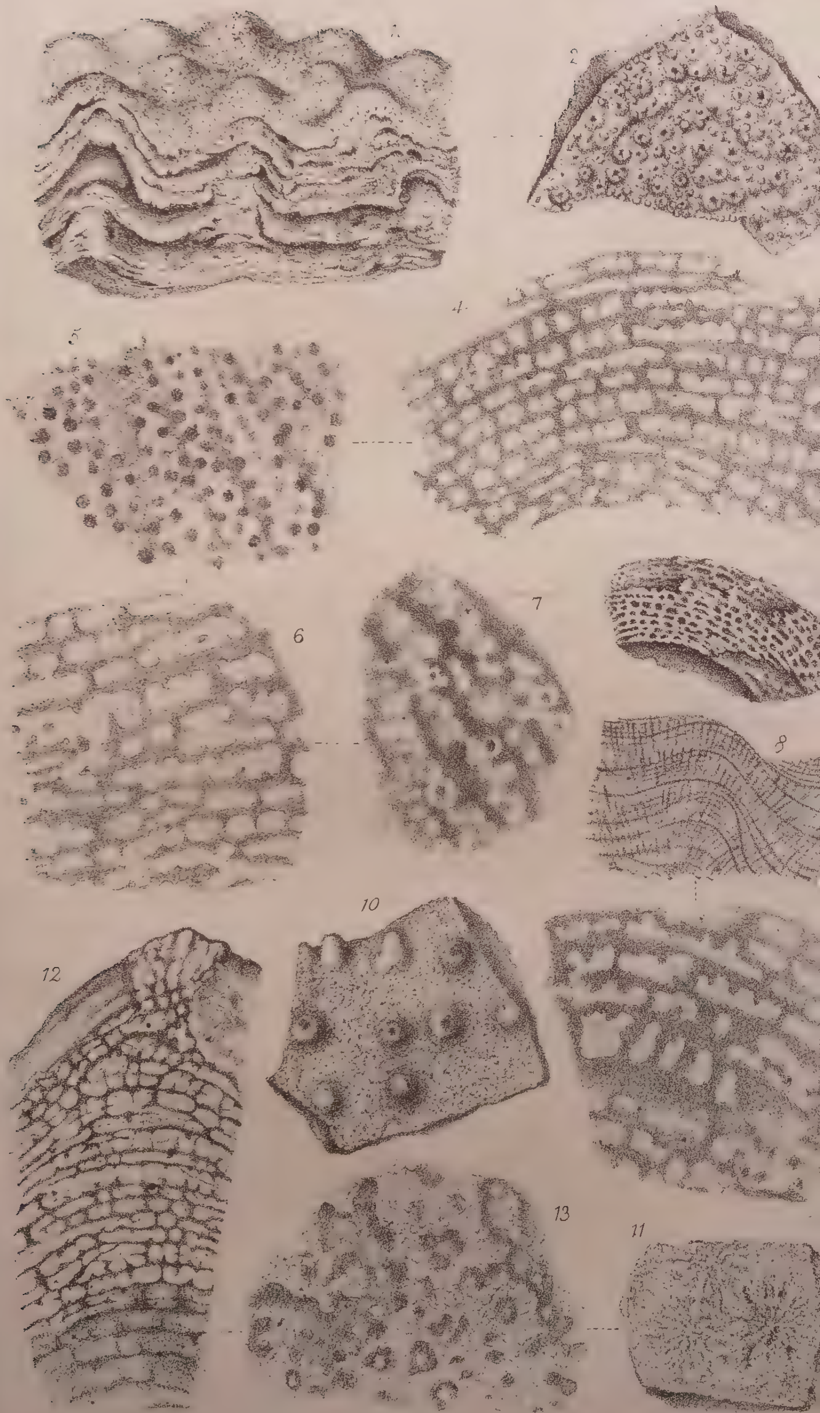
Fig. 6. A vertical transparent section of a small segment of *Stylodictyon columnare* under a 4-inch objective (= ×10 diam.). The more solid nature of the columns and the flatter sinuosities of the laminæ as contrasted with the looser reticular structure of *S. retiforme* are very evident. In *S. columnare*, also, the laminæ are very numerous and closely set in layers.

Fig. 7. The area comprising a single circular column of *S. columnare* in transverse section, under a 2-inch objective (= ×20 diam.).

Fig. 8. An oval-shaped columnar area from another transverse section of *S. columnare*, ×20 diam.

Figs. 7 and 8 equally exhibit a comparatively solid centre, surrounded by nearly equidistant series of circular chambers, and these again encircled by a more or less continuous set of chambers which give the appearance of a bounding external ring. Between these columnar areas the sarcode-chambers are somewhat less regular and closer set.

Fig. 9. *Stromatocerium canadense*, Nich. & Murie. A vertical transparent section, ×2½ diam. Specimen got from the Trenton Limestone, Couchiching, Canada. The multitudinous, wall-less vertical tubes and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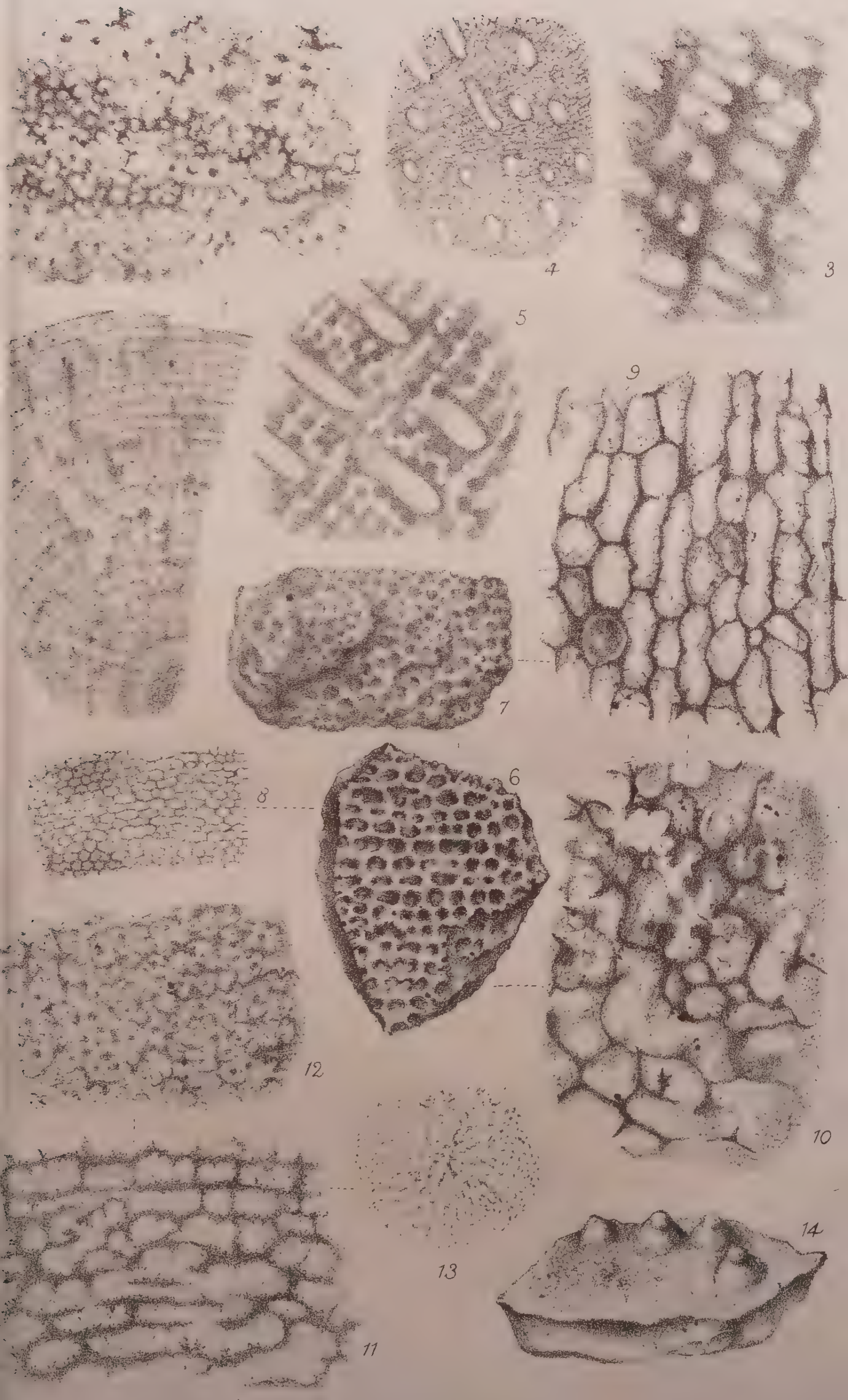
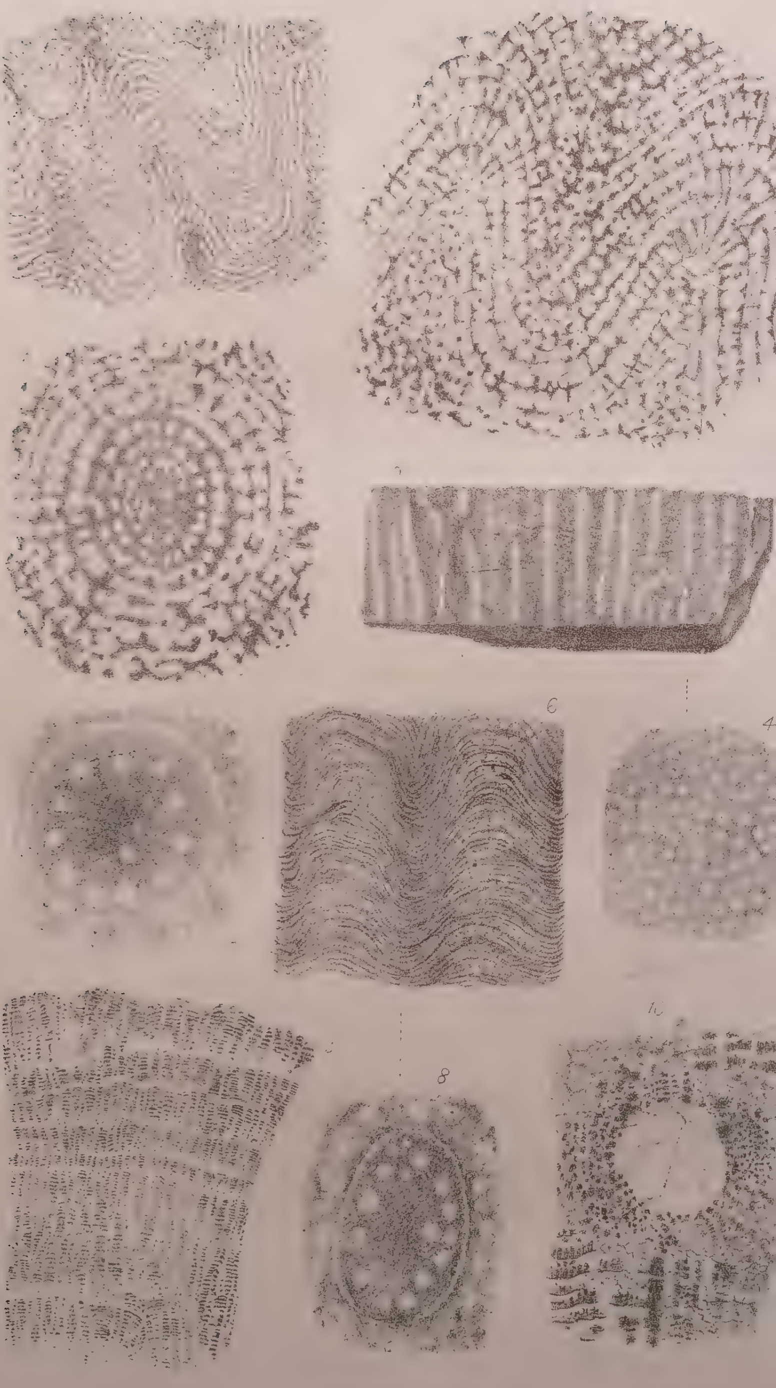


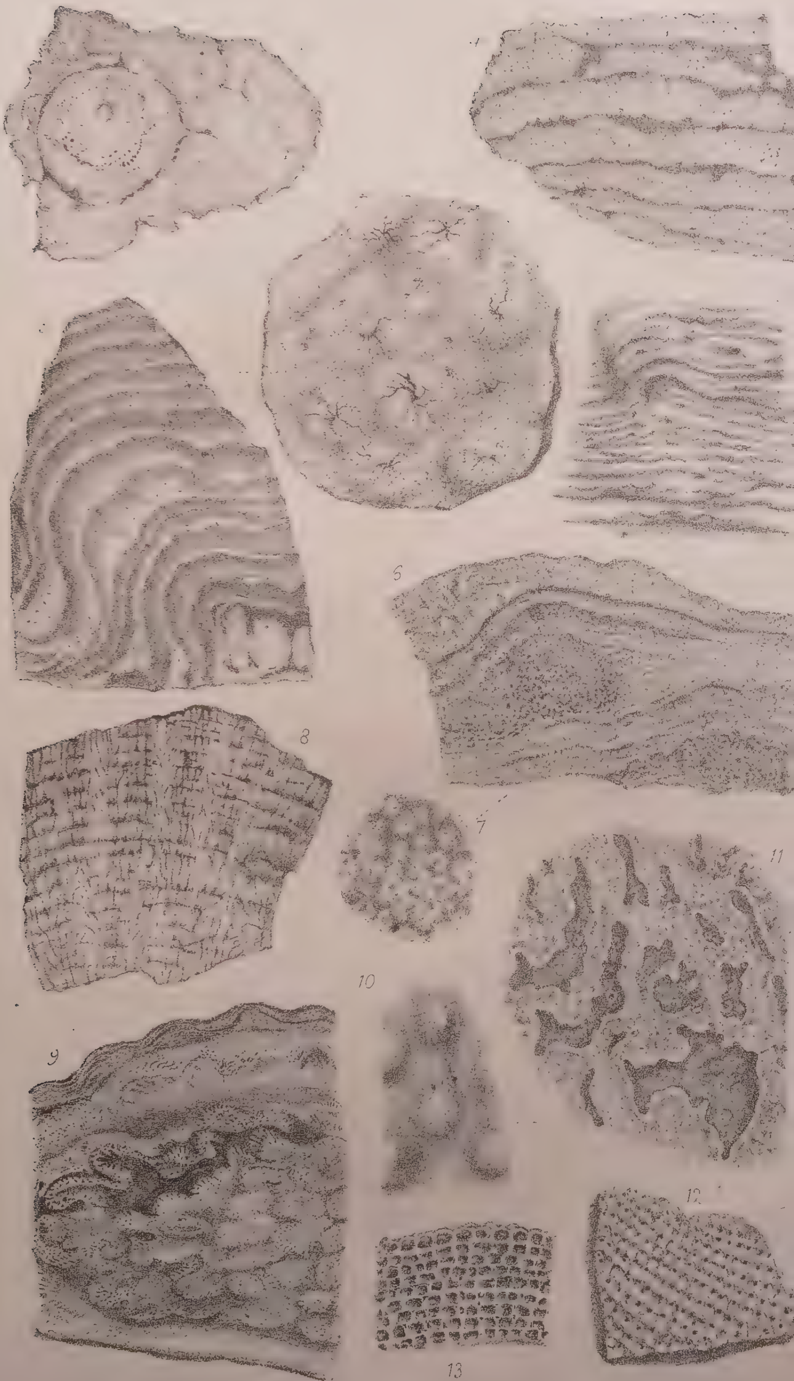
Berjeau lith.

STROMATOPORA, COENOSTROMA, CAUNOPORA,
CLATHRODICTYON & STYLODICTYON.

Hanhart imp.



Berjeau lith. STYLODICTYON & STROMATOCERIUM Hanhart imp.



PACHYSTROMA.

absence of the so-called vertical "radial pillars" are conspicuous characters.

Fig. 10. Sketch of a limited portion of another vertical section of *S. canadense*, examined with a 4-inch objective ($= \times 10$ diam.). In this a large vacuity surrounded by granular matter is prominent.

PLATE IV.

Fig. 1. *Pachystroma* sp.? Portion of the exterior undulating surface, of natural size, showing the superficial star-shaped depressions or "radiate water-canals."

Fig. 2. *Pachystroma antiqua*, Nich. & Murie. View of a small part of a larger specimen, of nat. size, exhibiting the wavy layers as seen in the exposed weathered condition. From the Upper Silurian (Niagara Limestone), Canada.

Fig. 3. A polished vertical section of a piece of *P. antiqua*, of nat. size, showing the contorted thick laminæ.

Fig. 4. A transparent microscopical specimen, being a vertical section of *P. antiqua*, about twice nat. size. In this the interlaminar structure is rather indefinite.

Fig. 5. A transverse or slightly tangential section of *P. antiqua*, also $\times 2$ diam. The circular area appears to correspond to the nodular eminences (possibly stellate systems) of the exterior crust, and in some respects bear a partial likeness to the columns of *Stylodictyon columnare*, though by far larger. What the artist has represented in dark dotted lines and broken inner circle are under the microscope apparently sarcode-chambers, on the whole rather indistinct.

Fig. 6. *Pachystroma* (*Syringostroma*) *densa*, Nich. A vertical transparent section, $\times 2$ diam. The sinuous layers in two places enclose sandy concretionary substance. The laminæ are relatively shallow and the small-sized chambers somewhat indefinite. From the Corniferous Limestone (Devonian), Ohio.

Fig. 7. View of a small portion of a tangential section of *P. densa*, under a 2-inch objective ($= \times 20$ diam.).

Fig. 8. A vertical transparent section of what appears to be a Stromatoporoid from the Trenton Limestone, Canada, and here represented of twice nat. size. There is a marked series of horizontal or concentric laminæ of average or considerable thickness. What appears to answer to vertical pillars are thin, linear, occasionally tubular-like threads, passing from one to two or more laminæ, and here and there joining each other so as to form oblong cells (=? sarcode chambers), these being filled throughout by crystalline matter. There are besides what correspond to columnar areas, which pass vertically upwards and seem formed of obliquely meeting cell (?) boundaries. The indefinite nature of this specimen makes us hesitate to describe it until further examination be instituted.

Fig. 9. A polished median vertical section of portion of another undetermined Stromatoporoid from the Cincinnati formation (Lower Silurian), Waynesville, Ohio. Drawn of nat. size, and placed in the Plate cross-wise to what may have been its natural position—that is, it may origi-

nally have been of a conical figure, thrice, or thereabouts, longer than that here shown. The skeleton is completely silicified, and what appears to answer to cavities are infiltrated with silica. Both upper and lower surfaces are of a roughened nodular character, though the view here given represents the lower border as plane. Both margins for a short distance inwards are markedly in thin undulating layers; deeper and centrally the layers assume minor ovoid figures, and in many, if not all, are radiating lines or pillars therefrom. These ovoid centres appear to correspond to the exterior nodular elevations (see fig. 10).

Fig. 10. A limited part of the surface of the preceding Stromatoporoid (fig. 9), of nat. size, showing the nodose elevations, and that besides these granular, they bear evidence of stellar tracery in agreement with the oval interior designs.

Fig. 11. A vertical transparent section of a portion of fig. 9 under an inch objective ($=\times 60$ diam.). It is difficult to interpret the microscopic appearances here presented other than by supposing the larger dark areas as openings or expansions of an intricate system of tubulation. In other portions of the slide, but not here shown, there were indications of a network comparable with that of some of the Lithistid sponges.

Fig. 12. The exterior surface of one of the layers of a fragment of the fossil Polyzoon *Eschara nobilis*, Michelin, $\times 2$ diam.

Fig. 13. A vertical section through a series of the layers of the same specimen of *E. nobilis*, also $\times 2$ diam. These figures are introduced for comparison with the structure of *Stromatopora*, &c.; the vertical section displays a great general resemblance to similar sections of *Stromatopora*, inasmuch as horizontal layers and vertical pillars are present.

Description of New Species and Genera of *Eumolpidæ*.

By Joseph S. Baly, Esq., M.R.C.S., F.L.S.

[Read December 20, 1877.]

List of Genera, Species, and their Habitat.

Aoria Mouhoti	Cambodia.
Eubrachis (n. g.) *spinipes*	Cameroons.
,, *indica*	Northern India.
Leprotes fulva	Tartary.
,, *Lewisi*	China, Japan.
Salodonta Simoni	Australia.
Parascela (n. g.).	
Cheiridea (n. g.) *Chapuisi*	Sierra Leone.
Colasposoma sellatum	Western Australia.
Ocnus pallidus	,, ,,

Pachnephorus torridus	Banks of the Niger.
„ *Bretinghami*	India.
„ *Lewisi*	China.
„ *porosa*	„
Eurydemus Jansoni	Guinea.
Bedelia persica	Persia.
Pseudocolaspis longicollis......	Southern India.
„ *Lefevrei*	Arabia.
„ *femorata*	South Africa.
Mouhotia (n. g.) *femorata*	Siam.
Syagrus rugifrons	South Africa.
Jansonius (n. g.) *alternatus* ..	Chili.

Genus AORIA, *Baly*.

AORIA MOUHOTI, n. sp. Breviter ovata, valde convexa, pallide piceo-fulva, subtus nitida; supra subopaca, fulvo-sericea; antennis extrorsum pedibusque nigris; thorace subgloboso, granuloso, fortiter subcrebre punctato; elytris thorace latioribus, e basi ad apicem attenuatis, convexis, infra basin leviter transversim depressis, humeris sat prominentibus, tenuiter sed distincte punctatis, interspatiis leviter ruguloso-granulosis. Long. $1\frac{1}{4}$ lin.

Hab. Cambodia, mountains of Laos, collected by the late M. Mouhot.

Head coarsely punctured, front impressed with a faint longitudinal groove; eyes and jaws black; anterior border of clypeus slightly concave-emarginate; antennæ more than two thirds the length of the body, three lower joints fulvous, the fourth piceous, the rest black, six outer joints slightly compressed. Thorax not longer than broad, subglobose; sides rounded; basal border narrowly margined, the median lobe distinctly produced, obtusely truncate; upper surface granulose, deeply punctured, sparingly clothed with short, erect hairs. Scutellum oblong-quadrate, its apex bisinuate. Elytra much broader than the thorax at the base, attenuated towards the apex, convex, faintly depressed transversely below the basilar space, the humeral callus prominent; finely punctured, interspaces rugose-granulose; on each elytron are a number of pale piceous points arranged in longitudinal rows, and corresponding to the punctate striæ on many other species of *Eumolpidæ*; surface clothed with suberect hairs, much longer than those on the thorax.

This insect, in external form, strongly resembles the smaller species of *Pseudocolaspis*.

Genus Eubrachis, *Dej. Cat.* (*Pseudocolaspis*, Chap., Fairm.).

Prothoracis episterni antica margine antico concavo aut recto, angulo antero-interno non libero; characteribus cæteris ut in *Pseudocolaspide*.

Type *Eubrachis cylindrica*.

On recently arranging my species of *Pseudocolaspis* I found that the insects were separable into two distinct generic groups: in the one, of which *P. cærulea*, Laporte, must be taken as the type, and which, consequently, must retain Laporte's name, the anterior margin of the prothoracic episternum is more or less convex, its antero-internal angle being free and not continuous with the anterior margin of the prosternum; in the second form, on which Dr. Chapuis has apparently drawn up his characters of *Pseudocolaspis*, the anterior margin of the episternum is straight or slightly concave, and its antero-internal angle is continuous with the outer angle of the prosternum. For this genus I propose to retain the name *Eubrachis*, used for these insects by Chevrolat in the 3rd edition of Dejean's Catalogue. The following short table will show at once the distinction between the two genera:—

Apical margin of anterior episternum convex or angulate, its antero-internal angle free .... *Pseudocolaspis*.
Apical margin of anterior episternum straight or concave, the antero-internal angle continuous with the prosternum .... *Eubrachis*.

Eubrachis spinipes, n. sp. Oblonga, valde convexa, nitida, subtus nigro-ænea, pedibus læte metallico-purpureis cyaneo tinctis; supra obscure cupreo-purpurea cyaneo et viridi-æneo tincta, pube grisea subsquamiformi parcus vestita; antennis piceo-rufis, viridi-æneo-micantibus, articulis ultimis quinque nigris; thorace subgloboso, rude rugoso, transversim elevato-strigoso; elytris thoracis basi multo latioribus, obovatis, convexis, infra basin late transversim depressis, callo humerali valde elevato, compresso; parce confuse punctatis, ante medium rude rugosis, pone medium vittis costiformibus interruptis, tuberculisque magnis in series longitudinales dispositis instructis; femoribus subtus spinis validis duabus arcuatis. Long. 2½ lin.

Hab. Guinea, Cameroons.

Head coarsely rugose; vertex covered with irregular longitudinal rugæ. Thorax subglobose, not longer than broad; sides moderately rounded; basal border narrowly margined, sinuate on either side the median lobe, the latter obtusely truncate; upper surface sparingly clothed with suberect griseous hairs, coarsely rugose, covered with irregular transverse elevated strigæ. Scutellum metallic purple, subquadrate, its apical margin bisinuate. Elytra much broader at the base than the thorax, attenuated from the base towards the apex; convex, broadly depressed transversely below the basilar space, the latter slightly thickened; humeral callus strongly elevated, compressed; surface sparingly clothed with erect, white, scale-like hairs, and remotely impressed with small but deep punctures, the anterior half coarsely rugose; the hinder half covered with interrupted costiform vittæ, which on the inner disk are broken up into large strongly raised nodosities. Body beneath and legs clothed with adpressed, white, scale-like hairs.

Eubrachis indica, n. sp. Elongata, subcylindrica, viridi-ænea, nitida, griseo-pubescens, pedibus nigro-æneis, trochanteribus, labro antennisque rufo-piceis, his extrorsum nigris; clypeo profunde subangulato-emarginato; thorace transverso, subgloboso, dorso depresso, apice constricto, fortiter sat crebre punctato, utrinque fovea magna impresso; elytris griseo-setosis, oblongis, fere parallelis, convexis, dorso paullo deplanatis, humeris prominentibus; subcrebre fortiter punctatis, punctis substriatim dispositis, singulis setula erecta grisea instructis. Long. $1\frac{4}{5}$ lin.

Hab. Northern India; Masuri (7000 feet above sea-level).

Head coarsely punctured, vertex swollen; front with an ill-defined longitudinal groove; anterior margin of clypeus deeply notched, the notch subangulate, its apex rounded; antennæ scarcely longer than the thorax, six lower joints rufo-piceous, more or less stained with black, five outer ones thickened, entirely black, apex of terminal joint acute. Thorax about a third broader than long; sides rounded, basal margin obsoletely sinuate on either side the median lobe, the latter obtusely truncate; upper surface subglobose, flattened on the disk, transversely depressed and constricted at the apex, narrowly margined at the base, surface clothed with adpressed hairs; strongly punctured, base with a faint longitudinal ridge. Scutellum scarcely broader than long, narrowed from base to apex, the apical margin obtuse,

the lateral ones sinuate; surface distinctly but not closely punctured. Elytra scarcely broader than the thorax, broadly oblong, sides nearly parallel, scarcely converging towards the apex; above convex, flattened along the suture; each elytron indistinctly excavated on the middle disk below the basilar space, the humeral callus prominent, compressed; rather strongly punctured, the punctures arranged in ill-defined longitudinal striæ; surface clothed with a number of erect, rigid, griseous hairs, each springing from a single puncture and forming longitudinal rows.

Genus Leprotes, *Baly.*

Leprotes fulva, n. sp. Elongata, subcylindrica, subtus picea, griseo-pilosa, pedibus sordide fulvis, femoribus apice tarsisque piceis; supra piceo-fulva, pube subsquamiformi concolori dense vestita; antennis nigris, basi piceis; thorace vix latiore quam longiore, lateribus rotundatis, antice breviter constrictis, subcylindrico, rugoso-punctato; elytris oblongis, parallelis, convexis, infra basin breviter transversim excavatis, fortiter substriatim punctatis. Long. 3 lin.

Hab. Mahlu San, coast of Tartary.

Whole body above densely clothed with linear, adpressed, scale-like hairs. Head coarsely punctured, front impressed with a longitudinal groove; clypeus not separated from the upper face, nearly glabrous, very slightly oblique, its anterior border very faintly sinuate; face above the clypeus concave; antennæ four fifths the length of the body, slender, filiform, the three or four lower joints pale piceous, more or less stained with nigro-piceous; basal joint thickened, subclavate, slightly curved; the second moderately thickened, two thirds the length of the first; the third slender, filiform, rather longer than the fourth. Thorax sub-cylindrical, slightly constricted at the apex, coarsely rugose-punctate. Scutellum wedge-shaped, its apex obtusely truncate, its surface rugose. Elytra broader than the thorax, parallel, subacutely rounded at the apex; above convex, faintly depressed below the basilar space, the latter very slightly thickened; strongly punctured, the punctures rather fainter towards the apex, arranged in irregular longitudinal rows; interspaces below the basilar space rugulose; on each elytron are several ill-defined, slightly raised, longitudinal vittæ. Legs slender, elongate.

LEPROTES LEWISI, n. sp. Elongata, subcylindrica, piceo-nigra aut nigra, squamulis albidisineariformibus sat dense vestita; antennis pallide rufo-piceis, extrorsum piceis; thorace vix longiore quam latiore, lateribus fere rectis, apice paullo convergentibus, subcylindrico, disco antice breviter excavato, rude rugoso-punctato; elytris oblongis, parallelis, convexis, infra basin distincte excavatis, spatio basilari distincte elevato, profunde substriatim punctatis (interspatiis rugulosis), utrinque vittis subelevatis nonnullis instructis; pedibus elongatis. Long. $3\frac{1}{2}$ lin.

Hab. China, Japan (collected in both localities by Mr. G. Lewis).

Whole body clothed with narrow, adpressed, acute, white scales. Head coarsely rugose-punctate, vertex and front impressed on the mesial line with a longitudinal groove; face above the clypeus concave; clypeus and labrum piceous, the former oblique, glabrous, its anterior margin angulate-marginate; antennæ more than three fourths the length of the body, slender, filiform, fulvo-piceous, the outer joints stained with piceous; first and second equal in length, the latter only slightly thickened, the third nearly one half longer than the second, equal in length to the fourth. Thorax scarcely longer than broad; sides nearly straight and parallel, only slightly converging at the apex; above subcylindrical, coarsely rugose-punctate; central portion of the middle disk obsoletely gibbous. Scutellum wedge-shaped, nearly twice as broad as long, its apex obtuse, the lower half of its surface rugose. Elytra broader than the thorax, parallel, subacutely rounded at the apex; convex, excavated below the basilar space, the latter distinctly thickened; coarsely and deeply punctured, the punctures arranged in ill-defined longitudinal rows, the puncturing rather finer towards the apex; interspaces shining, irregularly wrinkled; on each elytron are three or four slightly raised but distinct vittæ. Legs slender, elongate.

Genus SCELODONTA, *Westwood.*

SCELODONTA SIMONI, n. sp. Oblonga, convexa, cuprea, nitida, sat dense albido pubescens; antennis extrorsum nigris; thorace pube adpressa vestito impresso-strigoso, strigis distincte punctatis; elytris thorace multo latioribus, a basi ad apicem paullo attenuatis, convexis, infra basin leviter excavatis, humeris prominentibus; seriatim punctatis, pilis subsquamiformibus gracilibus suberectis in strias longitudinales dispositis vestitis. Long. 2 lin.

Hab. Australia, Rockhampton.

Head deeply punctured, granulose, sparingly clothed with coarse, adpressed, white hairs; lower portion of front impressed with a longitudinal groove; clypeus one half longer than broad, its apex separated from the face by an angular groove; anterior margin subangulate-emarginate, the angles of the notch each produced into an obtuse tooth; jaws nigro-piceous; antennæ slightly longer than the thorax, the five outer joints black. Thorax broader than long, sides rounded; basal margin oblique and slightly sinuate on either side; the median lobe sinuate; above convex, covered with sulcate punctured strigæ, transverse at the base, oblique towards the apex, entirely obsolete at the apex itself, where the puncturing becomes confused; basal border broadly margined. Scutellum rather broader than long, pentangular, its surface impressed with a few deep punctures. Elytra much broader at the base than the thorax, slightly attenuated towards the apex; convex, transversely excavated below the basilar space, the latter thickened, the humeral callus prominent; impressed with large but rather shallow punctures, arranged in numerous longitudinal rows; interspaces plane, irregularly wrinkled below the humeral callus and also below the basilar space; surface sparingly clothed with suberect, narrow, scale-like hairs, arranged in ill-defined longitudinal rows, much less numerous than the rows of punctures. Pleuræ densely clothed with adpressed white pubescence. Four hinder thighs each armed with an acute spine.

Scelodonta bidentata, described by me in the Trans. Entom. Soc. of London, p. 43 (April 1877), has been since described by M. Lefèvre in the French 'Annales' for 1877, p. 161, under the name of *Scelodonta egregia*.

Genus Parascela, n. gen.

Corpus oblongo-ovatum, valde convexum, pube suberecta vestitum. *Caput* exsertum, *facie* perpendiculari; *oculis* prominentibus, integris, apice orbito depresso munitis; *antennis* filiformibus, articulo basali incrassato, secundo et tertio æquilongis, utroque primum longitudine æquantibus. *Thorax* subglobosus, lateribus marginatis. *Elytra* thorace latiora, convexa, confuse punctata. *Pedes* mediocres; *femoribus* modice incrassatis, subampullatis, subtus dente acuto armatis; *tibiis* posticis quatuor extus ante apicem emarginatis; *unguiculis* appendiculatis. *Prosternum* subquadratum, lateribus concavis, apice trun-

cato, disco inter coxas transversim elevato; *episterno* antico, cum angulo antico non libero, margine antico recto.

Type *Parascela cribrata*, Schauf.

The insect on which I have founded the present genus differs from *Pseudocolaspis* (in which group it was placed by Schaufuss) in having appendiculated claws, notched hinder tibiæ, and also in the form of the prothoracic episternum: from *Eubrachis* it differs by the first two characters, and from *Scelodonta* by the absence of the deep frontal grooves and also in the appendiculated claws.

Genus Cheiridea, n. gen.

Corpus subelongatum, convexum, dorso glabrum. *Caput* exsertum, *facie* brevi, perpendiculari; *oculis* prominentibus; *antennis* gracilibus, filiformibus; *clypeo* subangulato-emarginato. *Thorax* latitudini longitudine æquali, subglobosus, subcylindricus, lateribus distincte marginatis, serrulatis. *Scutellum* pentagonum. *Elytra* thorace multo latiora, oblonga, punctato-striata. *Pedes* mediocres, *tibiis* intermediis extus ad apicem emarginatis; *unguiculis* dentatis. *Prosternum* anguste oblongum; *episterno* antico margine apicali recto, angulo antero-interno non libero.

Type *Cheiridea Chapuisi*.

Nearly allied to *Scelodonta*, separated by the absence of the supraorbital grooves and by the serrulate sides of the thorax.

Cheiridea Chapuisi, n. sp. Subelongata, convexa, nigra, nitida, supra cyaneo vix tincta; pedibus piceis labro, tarsis antennisque pallide piceo-fulvis; thorace subgloboso, crebre foveolato-punctato; elytris convexis, infra basin transversim excavatis et rugulosis, regulariter punctato-striatis, interspatiis elevato-costatis. Long. $1\frac{1}{2}$ lin.

Hab. Sierra Leone.

Head distinctly broader than long, rugose; clypeus not separated from the face, its anterior margin subangulate, emarginate; antennæ slender, rather more than half the length of the body, the three upper joints stained with piceous; basal joint subclavate, curved, thickened gradually towards the apex, the second oblong, rather more than half the length of the first, third to the fifth slender, each equal in length to the first. Thorax not longer than broad; sides rounded, the lateral margin denticulate, all the angles mucronate; upper surface subglobose, closely covered with deep round punctures, interspaces nitidous, minutely granulose. Scutellum longer than broad, pentangular, the lateral angles

nearly obsolete. Elytra much broader than the thorax, broadly oblong, sides parallel, the apex regularly rounded; above convex, transversely excavated below the basilar space, the humeral callus moderately thickened; regularly punctate-striate, the striæ sulcate, the punctures large, deeply impressed, those at the bases of the three or four inner striæ less regularly placed; interspaces strongly costate, the costæ on the transverse depression obsolete and replaced by irregular transverse rugæ.

Genus Colasposoma, *Laporte.*

Colasposoma sellatum. **Late oblongo-ovatum, convexum, subtus cupreo-æneum, femoribus nigro-æneis, aureo micantibus, tibiis tarsisque nigris æneo vix tinctis; supra igneo-ænea, antennis metallico-purpureis, extrorsum nigris; thorace fortiter subcrebre punctato, interstitiis nitidis; elytris rufo-igneis, dorso viridi-metallicis, fortiter confuse punctatis, punctis ad apicem minus fortiter impressis, pone medium prope suturam striatim dispositis, interspatiis lævibus, ad latus transversim elevato-rugosis. Long. 4 lin.**

Hab. Western Australia.

Head strongly punctured; vertex on either side above the eye rugose-strigose; front rugose, its mesial line impressed with a longitudinal groove; clypeus rugose-punctate, its apex not separated from the upper face, its anterior border sinuate; labrum piceous, jaws and eyes black, the latter faintly sinuate within, the interocular spaces coarsely punctured: antennæ about half the length of the body, four lower joints obscure metallic purple, the rest slightly thickened, black. Thorax nearly three times as broad as long; sides rounded, converging in front; all the angles mucronate; basal margin slightly oblique on either side, sinuate near the median lobe, the latter slightly produced, very obtusely truncate; upper surface strongly but not closely punctured, the interspaces shining, impunctate; basal border margined, the punctures immediately in front of its median lobe more crowded than on the disk. Scutellum semirotundate-ovate, its apex rounded, the side sinuate at the base. Elytra rather broader than the thorax, quadrate-oblong, regularly rounded at the apex; convex, faintly depressed transversely below the basilar space, the humeral callus moderately thickened, strongly but more distantly punctured than the thorax, the punctuation finer towards the apex, the punctures on the inner disk below its middle arranged in irregular longitudinal rows; interspaces smooth and shining, rather distantly

impressed on the inner disk with fine irregular reticulating strigæ; on the outer disk and at the apex the interspaces are thickened and form coarse irregular transverse rugæ. The general colour of the elytra is rufo-igneous; but on their dorsal surface is a common, broad, ill-defined, bright metallic green band, which extends from the base nearly to the apex of the elytra, the punctures on its surface, together with a very narrow sutural line, metallic purple.

Genus Ocnus, *Clark*.

Ocnus pallidus, n. sp. Elongatus, subcylindricus, flavus, nitidus, pube depressa vestitus; capite exserto; antennis robustis, ad apicem angustatis, articulis compressis, ultimis quatuor piceis; thorace vix latiore quam longiore, lateribus fere parallelis, leviter bisinuatis, subcylindrico, leviter ruguloso, fortiter minus remote punctato; elytris glabris, thorace paullo latioribus, parallelis, rude ruguloso-punctatis. Long. 4 lin.

Hab. Western Australia, Nicol Bay.

Head granulose, vertex rugulose, coarsely but not very closely punctured, sparingly clothed with adpressed white, scale-like, hairs; clypeus not longer than broad, trigonate, its apex depressed, not distinctly separated from the face; the sides rounded, the anterior margin transversely truncate, armed with two very short obtuse teeth; jaws nigro-piceous; antennæ nearly equal to the body in length, robust, attenuated towards the apex, the basal joint strongly thickened, subglobose, the second short, about half the length of the first, slightly thickened, the third to the seventh equal in length, each as long as the first two united, the third to the eleventh moderately compressed; eyes elongate-ovate, sinuate within. Thorax scarcely broader than long; sides nearly parallel, slightly converging from base to apex, slightly bisinuate, the anterior angle excurved; above subcylindrical, sparingly clothed with adpressed scale-like hairs, coarsely but not deeply rugulose-punctate, the middle disk with a broad, shallow, ill-defined longigitudinal depression, which extends from the base nearly to the apex. Scutellum semiovate, its apex subacute. Elytra broader than the thorax, subelongate, the sides parallel; above convex, coarsely but not very deeply rugulose-punctate; each elytron with three or four ill-defined vittæ, the one on the middle disk and another below the humeral callus more distinct than the others.

Genus Pachnephorus, *Redtenb.*

Pachnephorus torridus, n. sp. Elongatus, subcylindricus, piceus, nitidus, squamis oblongis bifidis albidis et fuscis dense vestitus, antennis piceo-fulvis; thorace fere æquilongo ac lato, profunde sat crebre punctato, squamis sordide albidis vestito; elytris oblongis, thorace latioribus, convexis, infra basin transverse excavatis, fortiter punctato-striatis, squamis fuscis et albidis variegatis. Long. $1\frac{2}{3}$ lin.

Hab. Banks of the Niger.

Head rotundate, coarsely punctured; vertex convex, closely covered with adpressed, whitish, oblong scales; front impressed with a longitudinal fovea, clothed with much narrower scales than those on the vertex; clypeus elevated, transverse, sparingly clothed with suberect silky hairs; labrum pale rufo-piceous; jaws black, their apices rufo-piceous; antennæ about a third the length of the body, piceo-fulvous. Thorax not longer than broad; sides straight and converging from the base to far beyond the middle, thence rounded and converging to the apex, upper surface convex, closely covered with large round punctures and clothed with dirty white scales. Elytra strongly punctate-striate, clothed with white and fuscous scales longer and narrower than those on the thorax, the white ones forming irregular patches on the surface. Legs and abdomen covered with adpressed linear scales.

Pachnephorus Bretinghami, n. sp. Oblongus, convexus, piceo-niger aut niger, nitidus, squamis adpressis bifidis albidis dense vestitus; antennis pedibusque sordide rufo-piceis; thorace vix latiore quam longiore, sat profunde punctato; elytris thorace latioribus, obovatis, convexis, infra basin excavatis, profunde punctato-striatis, interspatiis nitidis, leviter obsolete rugulosis, ad apicem convexiusculis; humeris prominentibus. Long. $1\frac{1}{3}$ lin.

Hab. India. Collected by Mr. Bretingham.

Head strongly punctured, excavated between the eyes; clypeus transverse, thickened at the base; antennæ more than a third the length of the body, five of the joints stained with fuscous. Thorax scarcely broader than long; sides straight and diverging from the base to far beyond the middle, thence rather abruptly rounded and converging to the apex; above subcylindrical, convex on the disk, deeply punctured, clothed with deeply bifid, narrowly oblong, adpressed scales. Elytra broader than the thorax, obovate, convex, each elytron deeply excavated below the basilar space, deeply and coarsely punctate-striate, the puncturing rather finer towards the apex; surface clothed with similar scales to those on the thorax;

here and there they are more densely congregated, and form ill-defined patches.

Pachnephorus Lewisi. Oblongus, convexus, piceo-niger, nitidus, subtus squamis albidis vestitus, supra squamis fuscis et albidis intermixtis depressis variegatus; antennis nigris, basi piceis; thorace paullo latiore quam longiore, profunde punctato; elytris convexis, infra basin excavatis, profunde punctato-striatis, striis infra basin prope suturam confusis et ibi punctis magis fortiter impressis, interspatiis nitidis, ad apicem convexiusculis. Long. $1\frac{1}{2}$ lin.

Hab. China. Collected by Mr. Lewis.

Head closely and deeply punctured; clypeus transverse, thickened at the base; clypeus piceous; antennæ rather longer than the head and thorax, the basal and the five upper joints black, the rest piceous. Thorax rather broader than long; sides diverging from the base to beyond the middle, thence rounded and converging to the apex; upper surface subcylindrical, convex on the disk, deeply punctured, clothed with oblong, bifid, fuscous and white scales, which form irregular patches on the surface. Elytra broadly oblong-ovate, excavated at the base near the suture, and again below the basilar space, deeply punctate-striate, the interspaces nitidous, slightly convex towards the apex and on the outer side; surface clothed with white and fuscous scales similar to those on the thorax, the former arranged in irregular patches; at the base, near the scutellum, the striæ are confused, that portion of the surface being impressed with a number of larger foveolate punctures. Body beneath and legs clothed with narrow whitish scales.

Pachnephorus porosa, n. sp. Elongatus, subcylindricus, niger, nitidus, squamis adpressis gracillimis bifidis griseis vestitus; pedibus piceis; antennis rufo-fulvis, extrorsum nigris; thorace convexo, profunde punctato; elytris profunde regulariter punctato-striatis, interspatiis nitidis tenuiter punctatis. Long. $1\frac{1}{3}$ lin.

Hab. China.

Head deeply and closely punctured; antennæ scarcely longer than the head and thorax, the five outer joints black, the six basal ones rufo-fulvous; labrum piceous. Thorax not longer than broad; sides diverging from the base to beyond the middle, thence rounded and converging to the apex; above convex, deeply impressed with large round punctures. Elytra broader than the thorax, oblong-ovate, convex, scarcely depressed below the basilar space, coarsely and deeply punctate-striate.

Genus Eurydemus, *Chapuis.*

Eurydemus Jansoni, n. sp. Oblongo-ovatis, fulvus, nitidus, antennis extrorsum thoracisque maculis duabus oblongis nigris; elytris regulariter fortiter punctato-striatis (interspatiis nitidis), utrinque plaga magna infra basin posita vix fere ad latus extensa nigra ornatis. Long. 2 lin.

Hab. Guinea, Cameroons.

Head nitidous, distinctly but not closely punctured; vertex with a faint longitudinal raised line, which terminates on the lower front in a perpendicular groove; jaws piceous; clypeus longer than broad, subcuneiform, its apex broadly truncate, its anterior margin concave-emarginate; antennæ nearly two thirds the length of the body, filiform, five lower joints fulvous, the rest black; basal joint incrassate, oval; the second oblong, two thirds the length of the first; the third slender, nearly twice as long as the second; eyes large, moderately distant. Thorax about one half broader than long; sides rounded and obliquely diverging from the base nearly to the middle, thence obliquely converging and slightly rounded to the apex, hinder angle mucronate; basal margin truncate on either side, the median lobe slightly produced, truncate; upper surface transversely convex, deflexed on the sides, in front finely and sparingly punctured; median portion of basal margin thickened; placed side by side of the middle disk are two narrowly oblong black patches. Scutellum rather longer than broad, trigonate, its apex obtuse. Elytra broadly oblong, and much broader than the thorax, sides parallel, the apex regularly rounded; above convex; each slightly but distinctly excavated below the basilar space, strongly punctate-striate, the punctures very large on the subbasal depression, smaller and less deeply impressed below the middle; interspaces plane, shining, impunctate; those on the excavated portion of the surface convex; on each elytron is a large black patch which extends from immediately below the basal margin to a short distance below the middle of the disk, and laterally from just within the outer margin to the third stria from the suture. All the thighs armed beneath with a strong acute spine.

This species differs from the typical form of the genus in the rather smaller and more widely separated eyes. This character varies in the two sexes of the same species. In *E. grandis* the eyes are much smaller and more distant from each other in the female

than in the male, from which latter sex Dr. Chapuis has apparently drawn up his diagnosis of the genus.

EURYDEMUS GRANDIS, *Baly, Journal of Entom.* i. p. 287 (*sub* Rhyparida), 1861.—Eurydemus insignis, *Chap. Gen. Col.* x. p. 334.

The insect described by me as *R. grandis* was sent to me as coming from New Caledonia. I have since had reason to suppose this locality to be erroneous, having recently received the species from Australia.

Genus BEDELIA, *Lefèvre.*

BEDELIA PERSICA, n. sp. Subelongata, subcylindrica, nitida, subtus piceo-nigra, pedibus fulvis, supra sparse griseo pubescens, fulva, antennis extrorsum piceis; capite fortiter punctato, vertice nigro-piceo; thorace transverso, convexo, late fortiter punctato, lateribus rotundatis, angulis mucronatis; elytris thorace latioribus, parallelis, convexis, fortiter punctato-striatis (interspatiis sat remote sed distincte tenuiter punctatis), utrinque vitta suturali maculaque oblonga a paullo ante ad longe pone medium extensa, interdum cum vitta suturali confluente, nigris. Long. 2½ lin.

Hab. Persia.

Clypeus not distinctly separated from the upper face, its anterior margin transversely truncate; jaws nigro-piceous; eyes reniform, deeply notched; antennæ rather more than half the length of the body, filiform, the six outer joints pale piceous, second joint thickened towards the apex, equal in length to the third, the latter slender. Thorax twice as broad as long across the middle; the sides rounded, all the angles mucronate; above convex, strongly punctured, rather sparingly clothed with adpressed griseous hairs; placed on the middle disk and extending nearly across from side to side of the thorax, is an irregular black transverse band. Elytra broader than the thorax, parallel, regularly rounded at the apex; convex, more finely and more sparingly pubescent than the head and thorax, strongly punctate-striate; the inner stria bifurcate at the base, the puncturing on its inner ramus irregularly placed; extreme apex of hinder femur piceous; all the femora armed beneath with a short spine.

This insect differs from the typical species in having the upper surface of its body sparingly pubescent.

Genus PSEUDOCOLASPIS, *Laporte*, nec *Chapuis.*

PSEUDOCOLASPIS LONGICOLLIS, n. sp. Breviter ovata, valde con-

vexa, cupreo-, aut viridi-ænea, nitida, griseo-setosa, tibiis, tarsis antennisque piceis, his extrorsum nigro-piceis ; thorace multo longiore quam latiore, basi convexo, hinc ad apicem subconico, profunde punctato; elytris basi thorace multo latioribus, ad apicem attenuatis, convexis, infra basin leviter transversim depressis, humeris valde prominentibus, setulis suberectis griseo vestitis; sat fortiter substriatim punctatis, interstitiis infra basin rugulosis; clypeo leviter concavo-emarginato. Long. 1½–2 lin.

Hab. Southern India.

Head coarsely punctured, vertex rugulose-strigose ; front impressed with a longitudinal groove ; anterior margin of clypeus concave; antennæ equal to the thorax in length, six lower joints pale rufo-piceous, the five outer ones pitchy black, these latter thickened and forming an elongate club, the seventh joint is obconic and slightly compressed, the eighth to the tenth are turbinate, and the eleventh ovate with its apex obtuse. Thorax one fourth longer than broad; sides rounded and diverging at the extreme base, thence obliquely converging to the apex; basal margin sinuate on either side, median lobe obtusely truncate ; upper surface convex at the base, thence subconic to the apex, clothed with adpressed griseous hairs, deeply impressed with large round punctures. Scutellum not longer than broad, pentangular, its surface coarsely punctured, the apical margin impunctate. Elytra much broader than the thorax at the base, narrowed from base to apex, the latter regularly rounded; above convex, transversely excavated below the basilar space, the humeral callus strongly elevated, compressed ; surface clothed with stout, suberect, griseous hairs, rather strongly punctured, the puncturing finer towards the apex, arranged in ill-defined longitudinal rows, interspaces just below the basilar space rugulose. Legs cupreo-æneous, tibiæ and tarsi piceous, the claws nigro-piceous, thighs armed beneath with a stout spine.

Pseudocolaspis Lefevrei, n. sp. Breviter ovata, valde convexa, nigro-picea, subopaca, squamulis adpressis griseis dense vestita; antennis rufo-piceis, extrorsum nigris; thorace paullo longiore quam latiore, subgloboso, antice subconico, profunde punctato; elytris thorace latioribus, a basi ad apicem attenuatis, convexis, infra basin transversim depressis, humeris valde prominentibus sat profunde; crebre punctatis ; disco exteriore (margine laterali excepto) rufo-piceo.

Hab. Arabia, Persia.

Body above clothed with adpressed griseous scales. Head

coarsely punctured; anterior margin of clypeus concave-emarginate, its extreme edge, together with the labrum, obscure piceous; antennæ scarcely longer than the thorax, six lower joints rufo-piceous, the five outer ones black, thickened and forming an elongated club. Thorax longer than broad, subglobose, subconic towards the apex, the basal margin sinuate on either side, the median lobe broadly truncate; upper surface closely covered with large, round, deeply impressed punctures, clothed with adpressed griseous scales; on either side of the disk is a broad, longitudinal, glabrous space. Scutellum scarcely broader than long, pentangular, densely clothed with griseous scales. Elytra much broader than the thorax at the base, attenuated towards the apex; convex, transversely depressed below the basilar space, the humeral callus strongly thickened; surface closely but rather less coarsely punctured than the thorax, interspaces just below the scutellum elevate-reticulate. All the femora armed beneath with a stout spine; tibiæ more or less stained with obscure piceous. Anterior episternum with its anterior border convex, and its antero-internal angle free.

Pseudocolaspis femorata, n. sp. Breviter ovata, valde convexa, viridi-ænea, aureo tincta, subtus griseo-pilosa, supra fere glabra; femoribus cupreo-aureis, tibiis tarsisque rufo-piceis; antennis nigris, basi rufo-piceis; capite granuloso, fortiter punctato, clypeo subangulato-emarginato; thorace fere æquilato ac longo, globoso, antice attenuato, granuloso, sat profunde et sat crebre punctato, punctis oblongis; elytris basi thorace multo latioribus, hinc ad apicem attenuatis, convexis, humeris valde elevatis, crebre et fortiter substriatim punctatis, interstitiis sparse argenteo-squamulosis, elevato-rugulosis, granulosis. Long. $1\frac{2}{3}$ lin.

Hab. South Africa.

Head coarsely and deeply punctured, the puncturing less crowded on the clypeus, the anterior margin of the latter subangulate-emarginate, the angles acute; antennæ slightly longer than the thorax, the six lower joints piceous, the five outer ones black. Thorax not longer than broad, subglobose, narrowed towards the apex, basal margin with the median lobe slightly produced, transversely truncate; surface closely covered with large, deeply impressed, oblong punctures; interspaces granulose, basal lobe transversely strigulose. Scutellum subquadrate, its apical margin bisinuate. Elytra much broader at the base than the thorax, attenuated from the base to the apex, the latter truncate; above

convex, transversely excavated below the basilar space, the humeral callus thickened, strongly elevated; sparingly clothed with short, suberect, silvery-white scales; coarsely and deeply punctured, the punctures indistinctly arranged in longitudinal striæ; interspaces rugose-granulose. Thighs cupreo-æneous, the intermediate pair less thickened than the others. Anterior episternum with its antero-internal angle free, the anterior margin convex.

Genus Mouhotia, n. gen.

Corpus breviter ovatum, valde convexum, supra glabrum. *Caput* in thoracem penitus immersum, perpendiculare; *oculis* anguste ovalibus, intus sinuatis, vix prominulis; *clypeo* a facie distincte separato, antice concavo-emarginato; *antennis* quam corporis dimidium longioribus, articulis basalibus quatuor cylindricis, cæteris compressis, leviter dilatatis. *Thorax* transversus, lateribus marginatis, a basi ad apicem convergentibus. *Scutellum* semiovatum. *Elytra* thorace multo latiora, subquadrato-ovata, valde convexa, regulariter punctato-striata, humeris prominentibus. *Pedes* robusti; *femoribus*, præsertim anticis, incrassatis, anticis et posticis spina brevi subtus armatis, intermediis muticis; *tibiis* posticis quatuor extus ante apicem emarginatis; *unguiculis* acute appendiculatis. *Prosternum* transversum, subquadratum, apice obtuse truncatum; *episterni antico* angulo antero-interno libero, margine antico convexo. *Mesosternum* breve, transversum.

Type *Mouhotia femorata*.

The transverse prosternum, the appendiculated claws, and the emargination of the four hinder tibiæ, combined with the general form, will at once distinguish this genus from *Typophorus* and its allies.

Mouhotia femorata, n. sp. Breviter ovata, valde convexa, subgibbosa, nitida; capite, thorace pedibusque nigris; pectore piceo; labro, pleuris, abdomine elytrisque rufis; his infra basin vix transversim depressis, regulariter punctato-striatis, interstitiis planis; thorace parce punctato. Long. 2 lin.

Hab. Cambodia, collected by the late Mr. Mouhot.

Head scarcely longer than broad, nitidous, impressed with a few deep punctures, front impressed in the middle with a narrow elongate fovea; upper orbit of eye narrowly excavated; interocular spaces separated from the front by an oblique row of punctures; clypeus much longer than broad, campanulate, distinctly separated from the face, its anterior margin concave-emarginate, either angle of the notch produced into an obtuse tooth; surface

strongly punctured; antennæ with the four lower joints slender, subcylindrical, piceous, the rest thickened and compressed, black. Thorax twice as broad at the base as long; sides obliquely rounded and converging from base to apex, the hinder angles mucronate; basal margin sinuate on either side, the median lobe very slightly produced, thickened, very obtusely rounded; upper surface transversely convex, subcylindrical at the apex, remotely impressed with large deep punctures, interspaces shining, impunctate; apical margin with a broad thickened edge. Scutellum shining, impunctate. Elytra much broader than the thorax, about one half longer than wide, subquadrate-ovate, very broadly rounded at the apex; very convex, faintly excavated below the basilar space, the humeral callus prominent; regularly punctate-striate, the puncturing much finer towards the apex, nearly obsolete on the basilar space; interspaces plane, shining, impunctate. All the thighs (more especially the anterior pair) thickened, ampullate, armed beneath with a short tooth, the intermediate pair unarmed.

Genus Syagrus, *Chapuis.*

Syagrus rugifrons, n. sp. Elongatus, subcylindricus, obscure cupreus, nitidus, scutello, capite pedibusque piceis, antennis obscure piceo-fulvis; capite rude rugoso; thorace vix latiore quam longiore, lateribus fere parallelis, subcylindrico, crebre foveolato-punctato; elytris thorace latioribus, oblongis, fortiter punctato-striatis, interspatiis costatis. Long. 3 lin.

Hab. South Africa.

Head very coarsely rugose-punctate; front impressed on the mesial line with a faint longitudinal groove; anterior border of clypeus angulate-emarginate; jaws black; antennæ slender, the basal joint broadly ovate, the second nearly equal in length to the first, moderately thickened, ovate, the third to the fifth nearly equal in length, each twice as long as the second. Thorax scarcely broader than long; sides nearly straight and parallel, converging at the apex; above subcylindrical, closely covered with large round punctures. Scutellum scarcely broader than long at the base, semirotundate, its apex acute. Elytra much broader than the thorax, oblong, the sides parallel, the apex rounded; above convex, not excavated below the basilar space, strongly and regularly punctate-striate, the ninth and tenth striæ from the suture abbreviated anteriorly below the humeral callus; interspaces convex on the anterior half of the inner disk, costate

on the hinder half, and on the whole of the outer disk, nitidous, sparingly impressed with a few minute punctures. Prosternum constricted anteriorly, its hinder half abruptly dilated. All the thighs armed beneath with a short tooth.

Genus Jansonius, n. gen.

Corpus anguste ovatum, convexum, squamulis adpressis brevibus vestititum. *Caput* modice exsertum, *facie* brevi, perpendiculari; oculis subrotundatis, intus leviter sinuatis; *antennis* corporis dimidio fere æquilongis, articulis ultimis quinque incrassatis. *Thorax* transversus, convexus. *Scutellum* semiovatum. *Elytra* thorace latiora, punctato-striata. *Pedes* modice robusti; *femoribus* posticis subtus spina acuta armatis; *tibiis* posticis quatuor extus ante apicem emarginatis; *unguiculis* appendiculatis. *Prosternum* planum, basi et apice ampliatum, lateribus subprofunde sinuatis; *episterno* antico margine apicali leviter convexo, angulo externo vix ad thoracis angulum anticum producto, angulo antero-interno libero.

Type *Jansonius alternatus.*

Nearly allied to *Pachnephorus*, separated from that genus by the more ovate form, the entirely different shape of the thorax, and by the much less convex and less produced anterior border of the prothoracic episternum.

Jansonius alternatus, n. sp. Ovatus, convexus, cupreus, nitidus; antennis nigris, his basi, femoribus basi, tibiis apice tarsisque piceo-rufis; thorace lateribus subangulatis, disco distincte punctato, punctis hic illic irregulariter congregatis; elytris thorace latioribus, convexis, pone medium squamulis brevissimis suberectis albidis parce vestitis, distincte (ad basin fortius) punctato-striatis, striis per paria approximantibus, interspatiis minute granulosis, alternis latioribus nitidis. Long. 1½ lin.

Hab. Chili.

Head granulose, rather closely punctured, clothed with adpressed, white, scale-like hairs; upper portion of front impressed with a deep fovea; labrum and jaws piceous; four lower joints of antennæ pale rufo-piceous, the basal one stained above with piceous, seven outer joints black, the five upper ones distinctly thickened. Thorax broader than long; sides moderately rounded, very obtusely angled in the middle; upper surface convex, very minutely granulose, impressed with round shallow punctures, which are crowded into large irregular patches on the surface. Scutellum pentagonal, its apex acute. Elytra much broader than the thorax, broadly oblong-ovate, convex, each elytron with a shallow exca-

vated space behind the basilar space; each impressed with eleven longitudinal rows of distinct punctures, more deeply impressed at the base, more especially the rows near the suture; the first shorter, the others approximating, but not very closely, in pairs, the space between each double row granulose and finely punctured, the broader spaces between the pairs nitidous and finely granulose.

Observations on Ants, Bees, and Wasps.—Part V. Ants. By Sir John Lubbock, Bart., M.P., F.R.S., F.L.S., D.C.L., Vice-Chancellor of the University of London.

[Read February 7, 1878.]

Ants.

Recollection of Friends.

In my last paper I recorded some experiments made on a nest of *Formica fusca* which I had divided into two parts. I found that while a stranger introduced into the nest was attacked, driven out, or even killed; and while strangers so introduced showed every sign of fear and an unmistakable desire to escape, friends, on the other hand, put back among their old companions, even after months of separation, were amicably received, and made themselves quite at home. Since my last paper I have continued the observations, as follows:—

The nest was divided on the 4th Aug. 1875.

Feb. 11, 1877. I put in two friends from the other division at 10 A.M. I looked at 10.15, 10.30, 11, 11.30, 12, 2, 4, and 6 P.M. They were on every occasion quite at home amongst the others.

Feb. 12. Put in three from the other division at 12. They were quite at home. I looked at them at 12.30, 1, 2, 4, and 6. Only for a minute or two at first one appeared to be threatened.

Feb. 13. Put in one friend from the other division. The ant was put in at 9.15 A.M., and visited at 9.30, 10, 11, 12, and 1.

Feb. 15. Do. The ant was put in at 10.15 A.M., and visited at 10.30, 11, 12, 1, 2, 3, and 4.

Feb. 19. Do. The ant was put in at 10 A.M., and visited at 10.15, 10.30, 11, 12, 1, and 2.

Mar. 11. Do. Do. at 9.30 A.M., visited at 10.30, 12.30, 2.30 and 5.30.

Mar. 12. Do. Do. at 10 A.M., visited at 12, 2, and 4.

Mar. 18. Put in two friends at 1 P.M., visited at 2 and 4.

April 21. Put in one friend at 9.30 A.M. At 10 she was all right, also at 12 and 4.

April 22. Put in two friends at 8.30. Visited them at 9 and 10, when they were almost cleaned. After that I could not find them; but I looked at 2, 4, and 6, and must have seen if they were being attacked.

April 23. Put in two friends at 12.32. Visited them at 1, 2, 3, 4, and 6. They were not attacked.

May 13. Put in two friends and a stranger at 7.45. At 9 the two friends were with the rest. The stranger was in a corner by herself. 11 do., 12 do. At 1 the friends were all right; the stranger was being attacked. 2, the friends all right; the stranger had been killed and dragged out of the nest. The next morning I looked again; the two friends were all right.

May 14. Put in the remaining three friends at 10. Visited them at 11, 12, 1, 2, 4, and 6. They were not attacked, and seemed quite at home.

This completed the experiment, which had lasted from Aug. 4, 1875, till May 14, 1877, when the last ones were restored to their friends. In no case was a friend attacked.

Though the above experiment seemed to me conclusive, I thought it would be well to repeat it with another nest.

I therefore separated a nest of *Formica fusca* into two portions on the 20th Oct. 1876.

On the 25th Feb. 1877, at 8 A.M. I put an ant from the smaller lot back among her old companions. At 8.30 she was quite comfortably established among them. At 9 do., at 12 do., and at 4 do.

June 8. I put two specimens from the smaller lot back as before among their old friends. At 1 they were all right and among the others. At 2 do. After this I could not distinguish them amongst the rest; but they were certainly not attacked.

June 9. Put in two more at the same hour. Up to 3 in the afternoon they were neither of them attacked. On the contrary, two strangers, from different nests, which I introduced at the same time, were both very soon attacked.

July 14. I put in two more of the friends at 10.15. In a few minutes they joined the others, and seemed quite at home. At 11 they were among the others. At 12 do., and at 1 do.

July 21. At 10.15 I put in two more of the old friends. At

10.30 I looked; neither were being attacked. At 11 do., 12 do., 2 do., 4 do., and 6 do.

Oct. 7. At 9.30 I put in two, and watched them carefully till 1. They joined the other ants and were not attacked. I also put in a stranger from another nest. Her behaviour was quite different. She kept away from the rest, running off at once in evident fear, and kept wandering about, seeking to escape. At 10.30 she got out; I put her back, but she soon escaped again. I then put in another stranger. She was almost immediately attacked. In the mean time the old friends were gradually cleaned. At 1.30 they could scarcely be distinguished; they seemed quite at home, while the stranger was being dragged about. After 2 I could no longer distinguish them. They were, however, certainly not attacked. The stranger, on the contrary, was killed and brought out of the nest.

This case, therefore, entirely confirmed the preceding, in which strangers were always attacked; friends were amicably received, even after a year of separation.

Thus, therefore, in these experiments, as in those previously recorded, the old acquaintances were evidently recognized. This is clear, because they were never attacked; while any ant from a different nest, even of the same species, would be set on and killed if she did not succeed in escaping from the nest. This recognition of old friends seems to me very remarkable. In one case the ants had not seen one another for more than a year.

Intelligence tested by Experiments with Honey.

To test their intelligence I made the following experiments:—I suspended some honey over a nest of *Lasius flavus* at a height of about ½ an inch, and accessible only by a paper bridge more than 10 feet long. Under the glass I then placed a small heap of earth. The ants soon swarmed over the earth on to the glass, and began feeding on the honey. I then removed a little of the earth, so that there was an interval of about ⅓ of an inch between the glass and the earth; but, though the distance was so small, they would not jump down, but preferred to go round by the long bridge. They tried in vain to stretch up from the earth to the glass, which, however, was just out of their reach, though they could touch it with their antennæ; but it did not occur to them to heap the earth up a little, though if they had moved only half a dozen

particles of earth they would have secured for themselves direct access to the food. This, however, never occurred to them. At length they gave up all attempts to reach up to the glass, and went round by the paper bridge. I left the arrangement for several weeks, but they continued to go round by the long paper bridge.

Further Test Experiments with Glycerine.

Again I varied the experiment as follows:—Having left a nest without food for a short time, I placed some honey on a small wooden brick surrounded by a little moat of glycerine about $\frac{1}{2}$ an inch wide and about $\frac{1}{10}$ of an inch in depth. Over this moat I then placed a paper bridge, one end of which rested on some fine mould. I then put an ant to the honey, and soon a little crowd was collected round it. I then removed the paper bridge; the ants could not cross the glycerine, they came to the edge and walked round and round, but were unable to get across, nor did it occur to them to make a bridge or bank across the glycerine with the mould which I had placed so conveniently for them. I was the more surprised at this on account of the ingenuity with which they avail themselves of earth for constructing their nests. For instance, wishing, if possible, to avoid the trouble of frequently moistening the earth in my nests, I supplied one of my ant-nests of *Lasius flavus* with a frame containing, instead of earth, a piece of linen, one portion of which projected beyond the frame and was immersed in water. The linen then sucked up the water by capillary attraction, and thus the air in the frame was kept moist. The ants approved of this arrangement, and took up their quarters in the frame. To minimize evaporation I usually closed the frames all round, leaving only one or two small openings for the ants, but in this case I left the outer side of the frame open. The ants, however, did not like being thus exposed; they therefore brought earth from some little distance, and built up a regular wall along the open side, blocking up the space between the upper and lower plates of glass, and leaving only one or two small openings for themselves. This struck me as very ingenious. The same expedient was, moreover, repeated under similar circumstances by the slaves belonging to my nest of *Polyergus*.

On the Origin of new Communities.

It is remarkable that, notwithstanding the labours of so many excellent observers, and though ants' nests swarm in every field and every wood, we do not yet know how their nests commence.

Three principal modes have been suggested. After the marriage-flight the young queen may either—

1. Join her own or some other old nest;

2. Associate herself with a certain number of workers, and with their assistance commence a new nest; or

3. Found a new nest by herself.

The question can of course only be settled by observation, and the experiments made to determine it have hitherto been indecisive.

Blanchard, indeed, in his work on the 'Metamorphoses of Insects' (I quote from Dr. Duncan's translation, p. 205), says:—"Huber observed a solitary female go down into a small underground hole, take off her own wings, and become, as it were, a worker; then she constructed a small nest, laid a few eggs, and brought up the larvæ by acting as mother and nurse at the same time."

This, however, is not a correct version of what Huber says. His words are:—"I enclosed several females in a vessel full of light humid earth, with which they constructed lodges, where they resided, some singly, others in common. They laid their eggs and took great care of them; and, notwithstanding the inconvenience of not being able to vary the temperature of their habitation, they reared some, which became larvæ of a tolerable size, but which soon perished from the effect of my own negligence" *.

It will be observed that it was the eggs, not the larvæ, which, according to Huber, these isolated females reared. It is true that he attributes the early and uniform death of the larvæ to his own negligence, but the fact remains that in none of his observations did an isolated female bring her offspring to maturity.

Other entomologists, especially Forel and Ebrard, have repeated the same observatious with similar results; and as yet in no single case has an isolated female been known to bring her young to maturity. Forel even thought himself justified in concluding, from his observations and from those of Ebrard, that such a fact could not occur.

Lepeletier de St. Fargeau † was of opinion that ants' nests originate in the second mode indicated above, and it is, indeed, far

* 'Natural History of Ants,' Huber, p. 121.

† Hist. Nat. des Ins. Hyménoptères, vol. i. p. 143.

from improbable that this may occur. No clear case has, however, yet been observed.

Under these circumstances I made the following experiments:—

1 *a*. I took an old, fertile, queen from a nest of *Lasius flavus*, and put her to another nest of the same species. The workers became very excited and killed her.

b. I repeated the experiment, with the same result.

c. Do. do. In this case the nest to which the queen was transferred was without a queen; still they would not receive her.

d and *e*. Do. do. do.

I conclude, then, that, at any rate in the case of *L. flavus*, the workers will not adopt an old queen from another nest.

2. I took an old, fertile queen of the same species and placed her by herself with damp earth, food, and water. In a few days, however, she died.

The following, however, shows that whether or not ants' nests sometimes originate in the two former modes or not, at any rate in some cases isolated queen ants are capable of giving origin to a new community.

On the 14th Aug. 1876, I isolated two pairs of *Myrmica ruginodis* which I found flying in my garden. I placed them with damp earth, food, and water, and they continued perfectly healthy through the winter. In April, however, one of the males died, and the second in the middle of May. The first eggs were laid between the 12th and 23rd April. They began to hatch the first week in June, and the first turned into a chrysalis on the 27th; a second on the 30th; a third on the 1st July, when there were also seven larvæ and two eggs. On the 8th there was another egg. On the 8th July a fourth larva had turned into a pupa. On the 11th July I found there were six eggs, and on the 14th about ten. On the 15th one of the pupæ began to turn brown, and the eggs were about 15 in number. On the 16th a second pupa began to turn brown. On the 21st a fifth larva had turned into a pupa, and there were about 20 eggs. On the 22nd July the first worker emerged, and a sixth larva had changed. On the 25th I observed the young worker carrying the larvæ about when I looked into the nest; a second worker was coming out. On July 28 a third worker emerged, and a fourth on the 5th Aug. The eggs appeared to be less numerous, and some had probably been devoured.

This experience shows that the queens of *Myrmica ruginodis*

have the instinct of bringing up larvæ and the power of founding communities. The workers remained about six weeks in the egg, a month in the state of larvæ, and 25–27 days as pupæ.

Communication between Ants.

Every one knows that if an ant or a bee in the course of her rambles has found a supply of food, a number of others will soon make their way to the store. This, however, does not necessarily imply any power of describing localities. A very simple sign would suffice, and very little intelligence is implied, if the other ants merely accompany their friend to the treasure which she has discovered. On the other hand, if the ant or bee can describe the locality, and send her friends to the food, the case is very different. This point, therefore, seemed to me very important; and I have made a number of observations bearing on it, some of which are recorded in my previous papers read before the Society.

The following may be taken as a type of what happens under such circumstances. On June 12 I put a *Lasius niger*, belonging to a nest which I had kept two or three days without food, to some honey. She fed as usual, and then was returning to the nest, when she met some friends, whom she proceeded to feed. When she had thus distributed her stores, she returned alone to the honey, none of the rest coming with her. When she had a second time laid in a stock of food, she again in the same way fed several ants on her way towards the nest; but this time five of those so fed returned with her to the honey. In due course these five would no doubt have brought others, and so the number at the honey would have increased.

Some species, however, act much more in association than others—*Formica fusca*, for instance, much less than *Lasius niger*. I have already given an illustration of what happens when a *L. niger* finds a store of food. The following is a great contrast. On the 28th March I was staying at Arcachon. It was a beautiful and very warm spring day, and numerous ants were coursing about on the flagstones in front of my hotel.

At about 10.45 I put a *F. fusca* to a raisin. She fed till 11.2, when she went almost straight to her nest, which was about 12 feet away. In a few minutes she came out again, and returned to the fruit, after a few small wanderings, at about 11.18. She then fed till 11.30, when she returned to the nest.

At 11.45 another ant accidentally found the fruit. I imprisoned her.

At 11.50 the first returned, and fed till 11.56, when she went off to the nest. On the way she met and talked with three ants, none of whom, however, came to the fruit. At 12.7 she returned, again alone, to the fruit.

On March 29 I repeated the same experiment. There were perhaps even more ants about than on the previous day.

At 9.45 I put one (N 1) to a raisin.	At 9.50 she went to the nest.
9.55 I put another (N 2) to the raisin.	10.0 ,, ,,
10.0 N 1 came back.	10.2 ,, ,,
10.7 ,, ,,	10.9 ,, ,,
10.11 N 2 ,,	10.13 ,, ,,
10.12 N 1 ,,	10.14 ,, ,,
10.13 put another (N 3) to the raisin.	10.18 ,, ,,
10.16 N 1 back.	10.17 ,, ,,
10.22 N 2 ,,	10.24 ,, ,,
(I here overpainted N 2, and she returned no more.)	
10.24 N 1 back.	At 10.26 went to the nest.
10.30 N 1 ,,	10.32 ,, ,,
10.33 N 3 ,,	10.35 ,, ,,
10.35 N 1 ,, (She met with an accident. At first she seemed a good deal hurt, but gradually recovered.)	
10.40 N 3 back.	At 10.46 she went to the nest.
10.46 a stranger came; I bottled her.	
10.47 ,, ,, ,,	
10.52 N 1 back.	10.54 ,, ,,
10.57 N 3 ,,	11.2 ,, ,,
11.8 N 3 ,,	11.13 ,, ,,
11.10 a stranger came; I removed her to a little distance.	
11.11 ,, ,, marked her N 4.	

11.16 N3 back.	At 11.18 went.	11.48 N1 came.	At 11.49 went.
11.23 N4 ,,	11.25 ,,	11.49 N4 ,,	11.50 ,,
11.24 N3 ,,	11.26 ,,	11.51 N1 ,,	11.53 ,,
11.27 N4 ,,	11.29 ,,	11.53 N3 ,,	11.56 ,,
11.31 N3 ,,	11.34 ,,	11.54 N4 ,,	11.56 ,,
11.32 N4 ,,	11.35 ,,	12.0 N3 ,,	12.2 ,,
11.40 N3 came.	11.42 ,,	,, N4 ,,	,, ,,
11.40 N4 ,,	,, ,,	,, N1 ,,	,, ,,
11.45 N3 ,,	11.47 ,,	12.5 N4 ,,	12.7 ,,
,, a stranger came.		12.6 N3 ,,	12.8 ,,

12.13 N3 came.	12.15 went.
12.14 N4 „	12.15 „
12.17 stranger came.	
12.19 N4 came.	12.20 „
12.20 N3 „	12.22 „
12.21 N1 „	12.25 „
12.25 N4 „	12.26 „
12.27 N3 „	12.28 „
12.30 N4 came.	12.32 went.
„ a stranger came.	
„ N3 (was disturbed)	12.37 „
12.38 N4 came.	12.40 „
12.42 N3 „	
12.47 N4 „	12.49 „

Thus during these three hours only six strangers came. The raisin must have seemed almost inexhaustible, and the watched ants in passing and repassing went close to many of their friends; they took no notice of them, however, and did not bring any out of the nest to cooperate with them in securing the food, though their regular visits showed how much they appreciated it.

Again (on the 15th July) an ant belonging to one of my nests of *Formica fusca* was out hunting. At 8.8 I put a spoonful of honey before her. She fed till 8.24, when she returned to the nest. Several others were running about. She returned as follows:—

9.10 to the honey, but was disturbed, ran away, and returned at 10.40. At 10.53 to the nest;

„	11.30	„	11.40	„
„	12.5, but was disturbed; she ran away again, but			
„	1.30.	At	1.44 to the nest;	
„	2.0	„	2.15	„
„	3.7	„	3.17	„
„	3.34	„	3.45	„
„	4.15	„	4.23	„
„	4.52	„	5.3	„
„	5.56	„	6.10	„
„	6.25	„	6.45	„
„	7.10	„	7.18	„
„	7.45	„	8.0	„
„	8.22	„	8.32	„
„	9.18	„	9.30	„
„	10.10	„	10.20	„

During the whole day she brought no friend, and only one other ant found the honey, evidently an independent discovery.

Experiments testing Communication by Sound.

To test the power which ants might have of summoning one another by sound, I tried the following experiments. I put out on the board where one of my nests of *Lasius flavus* was usually

fed, six small pillars of wood, about 1½ inch high, and on one of them I put some honey. A number of ants were wandering about on the board itself in search of food, and the nest itself was immediately above and about 12 inches from the board. I then put three ants to the honey, and when each had sufficiently fed, I imprisoned her, and put another; thus always keeping three ants at the honey, but not allowing them to go home. If, then, they could summon their friends by sound, there ought soon to be many ants at the honey. The results were as follows:—

Sept. 8. Began at 11 A.M. Up to 3 o'clock only seven ants found their way to the honey, while about as many ran up the other pillars. The arrival of these seven, therefore, was not more than would naturally result from the numbers running about close by. At 3 we allowed the ants then on the honey to return home. The result was that from 3.6, when the first went home, to 3.30, 11 came, from 3.30 to 4 no less than 43. Thus in four hours only 7 came; while it is obvious that many would have wished to come if they had known about the honey, because in the next three quarters of an hour, when they were informed of it, 54 came.

On the 10th Sept. we tried the same again, keeping as before three ants on the honey, but not allowing any to go home. From 12 to 5.30 only eight came. They were then allowed to take the news. From 5.30 to 6, 4 came; from 6 to 6.30, 4; from 6.30 to 7, 8; from 7.30 to 8 no less than 51.

On the 23rd Sept. we did the same again, beginning at 11.15. Up to 3.45 nine came. They were then allowed to go home. From 4 to 4.30, 9 came; from 4.30 to 5, 15; from 5 to 5.30, 19; from 5.30 to 6, 38. Thus in 3½ hours 9 came; in 2, when the ants were permitted to return, 81.

Again, on Sept. 30, I tried the same arrangement again, beginning at 11. Up to 3.30 seven ants came. We then let them go. From 3.30 to 4.30, 28 came; from 4.30 to 5, 51 came. Thus in four hours and a half only 7 came; while when they were allowed to return, no less than 79 came in an hour and a half.

It seems obvious, therefore, that in these cases no communication was transmitted by sound.

Experiments testing Affection.

To test the affection of ants belonging to the same nest for one another, I tried the following experiments. I took six ants from a nest of *Formica fusca*, imprisoned them in a small bottle, one end of which was left open, but covered by a layer of muslin. I then put the bottle close to the door of the nest. The muslin

was of open texture, the meshes, however, being sufficiently large to prevent the ants from escaping. They could not only, however, see one another, but communicate freely with their antennæ. We now watched to see whether the prisoners would be tended or fed by their friends. We could not, however, observe that the least notice was taken of them. The experiment, nevertheless, was less conclusive than could be wished, because they might have fed at night, or at some time when we were not looking. It struck me, therefore, that it would be interesting to treat some strangers also in the same manner.

On Sept. 2, therefore, I put two ants from one of my nests of *F. fusca* into a bottle, the end of which was tied up with muslin as described, and laid it down close to the nest. In a second bottle I put two ants from another nest of the same species. The ants which were at liberty took no notice of the bottle containing their imprisoned friends. The strangers in the other bottle, on the contrary, excited them considerably. The whole day one, two, or more ants stood sentry, as it were, over the bottle. In the evening no less than twelve were collected round it, a larger number than usually came out of the nest at any one time. The whole of the next two days, in the same way, there were more or less ants round the bottle containing the strangers; while, as far as we could see, no notice whatever was taken of the friends. On the 9th the ants had eaten through the muslin, and effected an entrance. We did not chance to be on the spot at the moment; but as I found two ants lying dead, one in the bottle and one just outside, I think there can be no doubt that the strangers were put to death. The friends throughout were quite neglected.

Sept. 21.—I then repeated the experiment, putting three ants from another nest in a bottle as before. The same scene was repeated. The friends were neglected. On the other hand, some of the ants were always watching over the bottle containing the strangers, and biting at the muslin which protected them. The next morning at 6 A.M. I found five ants thus occupied. One had caught hold of the leg of one of the strangers, which had unwarily been allowed to protrude through the meshes of the muslin. They worked and watched, though not, as far as I could see, with any system, till 7.30 in the evening, when they effected an entrance, and immediately attacked the strangers.

Sept. 24.—I repeated the same experiment with the same nest. Again the ants came and sat over the bottle containing the strangers, while no notice was taken of the friends.

The next morning again, when I got up, I found five ants round the bottle containing the strangers, none near the friends. As in the former case, one of the ants had seized a stranger by the leg, and was trying to drag her through the muslin. All day the ants clustered round the bottle, and bit perseveringly, though not systematically, at the muslin. The same thing happened all the following day.

These observations seemed to me sufficiently to test the behaviour of the ants belonging to this nest under these circumstances. I thought it desirable, however, to try also other communities. I selected, therefore, two other nests. One was a community of *Polyergus rufescens* with numerous slaves. Close to where the ants of this nest came to feed, I placed as before two small bottles, closed in the same way—one containing two slave ants from the nest, the other two strangers. These ants, however, behaved quite unlike the preceding, for they took no notice of either bottle, and showed no sign either of affection or hatred. One is almost tempted to surmise that the war-like spirit of these ants was broken by slavery.

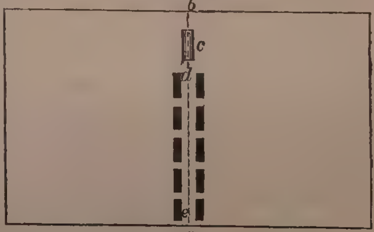
The other nest which I tried, also a community of *Formica fusca*, behaved exactly like the first. They took no notice of the bottle containing the friends, but clustered round and eventually forced their way into that containing the strangers.

It seems, therefore, that in these curious insects hatred is a stronger passion than affection.

Experiments showing the importance of the Sense of Smell to certain Ants.

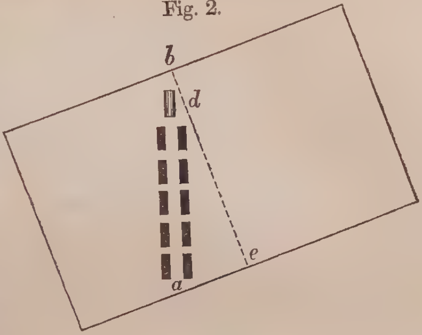
In order further to test how far ants are guided by sight and how much by scent, I tried the following experiment with *Lasius niger*. Some food was put out at the point *a* on a board measuring 20 inches by 12 (fig. 1), and so arranged that the ants in going straight to it from the nest would reach the board at the point *b*, and after passing under a paper tunnel, *c*, would proceed between five pairs of wooden bricks, each 3 inches in length and 1¾ in height. When they got to know their way, they went quite straight along the line *d e* to *a*. The board was then twisted as shown in fig. 2. The bricks and tunnel being arranged exactly in the same direction as before, but the board having been moved,

Fig. 1.



the line *d e* was now outside them. This change, however, did not at all discompose the ants; but instead of going, as before, through the tunnel and between the rows of bricks to *a*, they walked exactly along the old path to *e*.

Fig. 2.



I then arranged matters as before, but without the tunnel and with only three pairs of bricks (fig. 3). When an ant had got quite used to the path *d* to *e*, I altered the position of the bricks and food to *f* (fig. 4), making a difference of 8 inches in the position of the latter. The ant came as before, walked up to the first brick, touched it with her antennæ, but then followed her old line to *a*. From there she veered towards the food, and very soon found it. When she was gone, I altered it again, as shown in fig. 5; she returned after the usual interval, and went again straight to *a*; then, after some wanderings, to *f*, and at length, but only after a lapse of 25 minutes, found the food at *g*. These experiments were repeated more than once, and always with similar results. I then varied matters by removing the bricks, which, however, did not seem to make any difference to the ants.

Fig. 3.

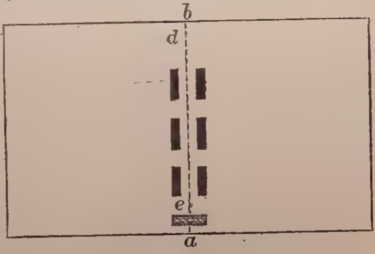


Fig. 4.

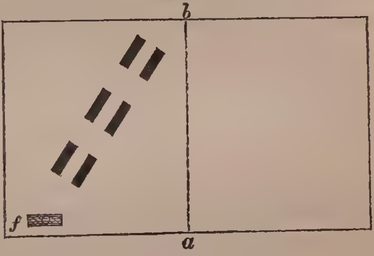
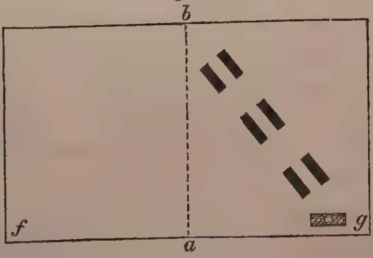


Fig. 5.



Experiments showing how Ants are affected by different coloured Lights and Media.

From the observations of Sprengel there could of course be little, if any, doubt, that bees are capable of distinguishing colours; but I have in my previous papers read before the Linnean Society recorded some experiments which put the matter beyond a doubt. Under these circumstances, I have been naturally anxious to ascertain, if possible, whether the same is the case with ants. I have, however, found more difficulty in doing so, because, as shown in the observations just recorded, ants find their food so much more by smell than by sight.

I tried, for instance, placing food at the bottom of a pillar of coloured paper, and then moving both the pillar and food. The pillar, however, did not seem to help the ant (*Lasius niger*) at all to find her way to the food. I then, as recorded in my previous paper, placed the food on the top of a rod of wood 8 inches high, and when the ant knew her way perfectly well to the food so that she went quite straight backwards and forwards to the nest, I found that if I moved the pillar of wood only six inches, the ant was quite bewildered, and wandered about backwards and forwards, round and round, and at last only found the pillar, as it were, accidentally.

Under these circumstances, I could not apply to ants those tests which had been used in the case of bees. At length, however, it occurred to me that I might utilize the dislike which ants, when in their nests, have to light. Of course they have no such feeling when they are out in search of food; but if light is let in upon their nests, they at once hurry about in search of the darkest corners, and there they all congregate. If, for instance, I uncovered one of my nests and then placed an opake substance over one portion, the ants invariably collected in the shaded part.

I procured, therefore, four similar strips of glass, coloured respectively green, yellow, red, and blue, or, rather, violet. The yellow was rather paler in shade, and that glass consequently rather more transparent than the green, which, again, was rather more transparent than the red or violet. I then laid the strips of glass on one of my nests of *Formica fusca* containing about 170 ants. These ants, as I knew by many previous observations, seek darkness, and would certainly collect under any opake substance.

I then, after counting the ants under each strip, moved the colours gradually at intervals of about half an hour, so that each

should by turns cover the same portion of the nest. The results were as follows—the numbers indicating the approximate numbers of ants under each glass (there were sometimes a few not under any of the strips of glass):—

1.	Green.	Yellow.	Red.	Violet.
	50	40	80	0
2.	Violet.	Green.	Yellow.	Red.
	0	20	40	100
3.	Red.	Violet.	Green.	Yellow.
	60	0	50	50
4.	Yellow.	Red.	Violet.	Green.
	50	70	1	40
5.	Green.	Yellow.	Red.	Violet.
	30	30	100	0
6.	Violet.	Green.	Yellow.	Red.
	0	14	5	140
7.	Red.	Violet.	Green.	Yellow.
	50	0	40	70
8.	Yellow.	Red.	Violet.	Green.
	40	50	1	70
9.	Green.	Yellow.	Red.	Violet.
	60	35	65	0
10.	Violet.	Green.	Yellow.	Red.
	1	50	40	70
11.	Red.	Violet.	Green.	Yellow.
	50	2	50	60
12.	Yellow.	Red.	Violet.	Green.
	35	55	0	70

Adding these numbers together, there were, in the twelve observations, under the red 890, under the green 544, under the yellow 495, and under the violet only 5. The difference between the red and the green is very striking, and would doubtless have been more so, but for the fact that when the colours were transposed the ants which had collected under the red sometimes remained quiet, as, for instance, in cases 7 and 8. Again, the difference between the green and yellow would have been still more marked but for the fact that the yellow always occupied the position last held by the red, while, on the other hand, the green had some advantage in coming next the violet. In considering the differ-

ence between the yellow and green, we must remember also that the green was decidedly more opake than the yellow.

The case of the violet glass is more marked and more interesting. To our eyes the violet was as opake as the red, more so than the green, and much more so than the yellow. Yet, as the numbers show, the ants had scarcely any tendency to congregate under it. There were nearly as many under the same area of the uncovered portion of the nest as under that shaded by the violet glass.

Lasius flavus also showed a marked avoidance of the violet glass.

I then experimented in the same way with a nest of *Formica fusca*, in which there were some pupæ, which were generally collected in a single heap. I used glasses coloured dark yellow, dark green, light yellow, light green, red, violet, and dark purple. The colours were always in the preceding order, but, as before, their place over the nest was changed after every observation.

To our eyes the purple was almost black, the violet and dark green very dark and quite opake; the pupæ could be dimly seen through the red, rather more clearly through the dark yellow and light green, while the light yellow were almost transparent. There were about 50 pupæ, and the light was the ordinary diffused daylight of summer. (See Table, p. 281.)

These observations show a marked preference for the greens and yellows. The pupæ were 6½ times under dark green, 3 under dark yellow, 3½ under red, and once each under light yellow and light green, the violet and purple being altogether neglected.

I now tried the same ants under the same colours, only in the sun; and placed a shallow dish containing some 10 per cent. solution of alum sometimes over the yellow, sometimes over the red. I also put four thicknesses of violet glass, so that it looked almost black. (See Table, p. 282.)

Under these circumstances, the pupæ were placed under the red 7½ times, dark yellow 5½, and never under the violet, purple, light yellow, dark or light green.

The following day I placed over the same nest, in the sun, dark green glass, dark red and dark yellow (two layers of each). In nine observations the pupæ were carried 3 times under the red and nine times under the yellow.

I then tried a similar series of experiments with *Lasius niger*, using part of a nest in which were about 40 pupæ, which were generally collected in a single heap all together. As before, the glasses were moved in regular order after each

1.	Dark yellow.	Dark green.	Light yellow.	Light green.	Red.	Violet.	Purple.	The pupæ were placed under dark green.
2.	Purple.	Dark yellow.	Dark green.	Light yellow.	Light green.	Red.	Violet.	,, ,, ,,
3.	Violet.	Purple.	Dark yellow.	Light yellow.	Dark green.	Light green.	Red.	,, ,, light yellow.
4.	Red.	Violet.	Purple.	Dark yellow.	Light yellow.	Dark green.	Light green.	,, ,, dark green.
5.	Light green.	Red.	Violet.	Purple.	Dark yellow.	Light yellow.	Dark green.	,, ,, dark yellow.
6.	Dark green.	Light green.	Red.	Violet.	Purple.	Dark yellow.	Light yellow.	,, ,, ,,
7.	Light yellow.	Dark green.	Light green.	Red.	Violet.	Purple.	Dark yellow.	,, ,, light green.
8.	Dark yellow.	Light yellow.	Light yellow.	Light green.	Red.	Violet.	Purple.	,, ,, dark green.
9.	Purple.	Dark yellow.	Dark yellow.	Dark green.	Light green.	Red.	Violet.	,, ,, ,,
10.	Violet.	Purple.	Purple.	Light yellow.	Dark green.	Light green.	Red.	,, ,, red.
11.	Red.	Red.		Dark yellow.	Light yellow.	Dark green.	Light green.	,, ,, dark green.
12.	Light yellow.	Purple.	Light green.	Dark yellow.	Dark green.	Violet.	Red.	,, ,, dark green 30; red 30.
13.	Red.	Light yellow.	Purple.	Light green.	Dark yellow.	Dark green.	Violet.	,, ,, ,, ,,
14.	Violet.	Red.	Light yellow.	Purple.	Light green.	Dark yellow.	Dark green.	,, ,, ,, ,,
15.	Dark green.	Violet.	Red.	Light yellow.	Purple.	Light green.	Dark yellow.	,, ,, dark yellow 20; red 40.

1.	Dark yellow.	Dark green.	Violet.	Red.	Light yellow.	Purple.	Light green.	Pupæ	under red.
2.	Light green.	Dark yellow.	Dark green.	Violet.	Red.	Light yellow.	Purple.	,,	,,
3.	Purple.	Light green.	Dark yellow.	Dark green.	Violet.	Red.	Light yellow.	,,	,,
4.	Light yellow.	Purple.	Light green.	Dark yellow.	Dark green.	Violet.	Red and alum solution.	,,	dark yellow.
5.	Red.	Light yellow.	Purple.	Light green.	Dark yellow.	Dark green.	Violet.	,,	red 20, dark yellow 40.
6.	Violet.	Red.	Light yellow.	Purple.	Light green.	Dark yellow and alum solution.	Dark green.	,,	dark yellow.
7.	Dark green.	Violet.	Red.	Light yellow.	Purple.	Light green.	Dark yellow and alum solution.	,,	,,
8.	Dark yellow and alum solution.	Dark green.	Violet.	Red.	Light yellow.	Purple.	Light green.	,,	,,
9.	Light green.	Dark yellow and alum solution.	Dark green.	Violet.	Red.	Light yellow.	Purple.	,,	,,
10.	Purple.	Light green.	Dark yellow.	Dark green.	Violet.	Red and alum solution.	Light yellow.	,,	red.
11.	Red and alum solution.	Light yellow.	Light green.	Dark yellow.	Dark green.	Violet.	Purple.	,,	,,
12.	Purple.	Red and alum solution.	Light yellow.	Light green.	Dark yellow.	Dark green.	Violet.	,,	,,
13.	Dark green.	Violet.	Red and alum solution.	Light yellow.	Light green.	Dark yellow.	Purple.	,,	,,

experiment; and I arranged them so that the violet followed the red. As far, therefore, as position was concerned, this gave violet rather the best place. The glasses used were dark violet, dark red, dark green, and yellow, the yellow being distinctly the most transparent to our eyes.

Experiment.		Experiment.	
1.	Pupæ under yellow.	17.	Pupæ under yellow.
2.	„ „	18.	„ „
3.	„ „	19.	„ red.
4.	„ „	20.	„ „
5.	„ „	21.	„ yellow.
6.	„ „	22.	„ „
7.	„ green.	23.	„ „
8.	„ „	24.	„ red.
9.	„ red.	25.	„ yellow.
10.	„ yellow.	26.	„ red.
11.	„ red.	27.	„ „
12.	„ yellow.	28.	„ „
13.	„ „	29.	„ „
14.	„ red.	30.	„ yellow.
15.	„ green.	31.	„ red.
16.	„ „	32.	„ green.

I now put two extra thicknesses of glass over the red and green.

33.	Pupæ under red.	37.	Pupæ under red.
34.	„ yellow.	38.	„ „
35.	„ red.	39.	„ yellow.
36.	„ yellow.	40.	„ red.

The result is very striking, and in accordance with the observations on *Formica fusca*. In 40 experiments the pupæ were carried under the yellow 19 times, under the red 16 times, and under the green 5 times only, while the violet was quite neglected. After the first twenty observations, however, I removed it.

I then tried a nest of *Cremastogaster scutellaris* with violet glass, purple glass, and red, yellow, and green solutions, formed respectively with fuchsine, bichromate of potash, and chloride of copper. The purple looked almost black, the violet very dark; the red and green, on the contrary, very transparent, and the yellow even more so. The yellow was not darker than a tincture of saffron. The latter indeed, to my eye, scarcely seemed to render the insects under them at all less apparent; while under

the violet and purple I could not trace them at all. I altered the relative positions as before. The nest contained about 50 larvæ and pupæ.

Observation.					
1.	Violet gl.	Purple gl.	....	Bichr. pot.	Fuchsine.
2.	....	Bichr. pot.	Fuchsine.	Violet gl.	Purple gl.
3.	Fuchsine.	Violet gl.	Purple gl.	....	Bichr. pot.
4.	Green.	Bichr. pot.	Violet gl.	Purple gl.	Fuchsine.
5.	Violet gl.	Purpl. gl.	Fuchsine.	....	Bichr. pot.
6.	Fuchsine.	....	Bichr. pot.	Purple gl.	Violet gl.
7.	Violet gl.	Fuchsine.	....	Bichr. pot.	Purple gl.
8.	Purple gl.	Violet gl.	Fuchsine.	....	Bichr. pot.
9.	Bichr. pot.	Purple gl.	Violet gl.	....	Bichr. pot.
10.	Fuchsine..	....	Bichr. pot.	Purpl. gl.	Violet gl.

Pupæ and larvæ half under the yellow and half under the green.

I then poured out half the yellow and green solutions and filled them up with water, making them even lighter in colour as before.

Observation.						
12.......	Purple gl.	....	Violet gl.	Fuchsine.	Bichr. pot.	Pupæ and larvæ half under the yellow and half under the green.
13.......	Bichr. pot.	Purpl. gl.	....	Violet gl.	Fuchsine.	

Thus in every case the larvæ and pupæ were brought under the yellow or the green.

Aug. 20.—Over a nest of *Formica fusca* containing about 20 pupæ I placed violet glass, purple glass, a weak solution of fuchsine (carmine), the same of chloride of copper (green), and of bichromate of potash (yellow, not darker than saffron).

1.	Violet.	Purple.	Green.	Yellow.	Red.	The pupæ were placed under the yellow.
2.	Red.	Violet.	Purple.	Green.	Yellow.	" " "
3.	Yellow.	Red.	Violet.	Purple.	Green.	" " "
4.	Green.	Yellow.	Red.	Violet.	Purple.	" " "
5.	Purple.	Green.	Yellow.	Red.	Violet.	" " "
6.	Violet.	Purple.	Green.	Yellow.	Red.	" " "
7.	Red.	Violet.	Purple.	Green.	Yellow.	" " "
8.	Yellow.	Red.	Violet.	Purple.	Green.	" " green and yellow.
9.	Green.	Yellow.	Red.	Violet.	Purple.	" " yellow.
10.	Purple.	Green.	Yellow.	Red.	Violet.	" " green and yellow.
11.	Violet.	Purple.	Green.	Yellow.	Red.	" " yellow.
						" " "

Here, again, in every case the pupæ were brought under the yellow or the green.

I then tried a nest of *Lasius flavus* with the purple glass, violet glass, the very weak bichromate of potash, and chloride of copper as before.

Observation.							
1.	Yellow.	Green.	Purple.	Violet.	The pupæ were brought	under the	yellow and green.
2.	Violet.	Yellow.	Green.	Purple.	,,	,,	green.
3.	Purple.	Violet.	Yellow.	Green.	,,	,,	,,
4.	Green.	Purple.	Violet.	Yellow	,,	,,	,,
5.	Yellow.	Green.	Purple.	Violet.	,,	,,	yellow.
6.	Violet.	Yellow.	Green.	Purple.	,,	,,	green.

The results, then, were the same as in the previous cases.

In these experiments, then, the violet and purple affected the ants much more strongly than the yellow and green.

It is curious that the coloured glasses appear to act on the ants (speaking roughly) as they would, or, I should rather say, inversely as they would, on a photographic plate. It might even be alleged that the avoidance of the violet glass by the ants was due to the chemical rays which are transmitted. From the habits of these insects such an explanation is very improbable. If, however, the preference for the other coloured glasses to the violet was due to the transmission and not to the absorption of rays—that is to say, if the ants went under the green rather than the violet because the green or red transmitted rays which were agreeable to the ants, and which the violet glass, on the contrary, stopped—then, if the violet was placed over the other colours, they would become as distasteful to the ants as the violet itself. On the contrary, however, whether the violet glass was placed over the others or not, the ants equally readily took shelter under them. Obviously, therefore, the ants avoid the violet glass because they dislike the rays which it transmits.

Mr. Busk suggested that as the red glass stops the chemical rays more effectually than the yellow or green, while the violet is most transparent to them, and as the ants prefer the red glass to the yellow or green, and these, again, to the violet, possibly the explanation might be that the chemical rays were peculiarly distasteful to them. To test this, therefore, I made some experiments with fluorescent liquids which Mr. Hanbury was kind enough to procure for me from Mr. Benger, of Manchester. They were prepared by M. Caro, of Manheim. One was opake grass-green by reflected light and orange by transmitted; one violet by transmitted light and red by reflected; and a third green by transmitted and red by reflected light. I believe their exact chemical composition is not known, but that, in all cases, fluorescine is the principal ingredient. They stop the chemical rays, or rather turn them into visible rays. The action takes

place altogether at the surface of the liquids, so that it is not necessary to use any large quantity. I poured them into shallow glass cells about ½ inch deep, which I put, as before, over the ants. If now they were affected mainly by the chemical rays, it must appear to them to be dark under these solutions. This, however, was not the case. The solutions seemed to make no difference to them. I also tried quinine and uranium glass with the same effect.

In order to ascertain what colours were transmitted by these several media, I then tested them with the spectroscope, and with the following results:—

The violet glass transmitted violet, blue, some green and yellow to about the line D in the spectrum or a trifle beyond.

„ „	(double)	transmitted	violet and blue with tinge of red.
green glass		„	most of blue, and about to line "*a*."
„ „	(double)	„	green, yellow, and red to about line "C."
„ „	(dark)	„	green and some yellow.
yellow „		„	the spectrum from red end to about half-way between "F" and "S."
„ „	(dark)	„	from red to end of green about "F."
red „		„	red with a touch of orange.
„ „	(double)	„	only red.
purple „		„	a little violet, a little yellow, orange, and red.

Amm. sulph. of copper (blue) transmitted violet and blue only.

Chloride of copper ...	(green)	„	green, an edging of blue, and faint yellow with an edging of orange.
Saffron..................		„	every thing except violet and blue.
Bichromate of potash	(orange)	„	red, orange, yellow, and very little green.
„	(very pale yellow)	„	red, orange, yellow, and green.
Fuchsine	(carmine)	„	red only.
Solution of carmine ..	„	„	„
Solution of iodine	„	„	red, orange, and a very little yellow.

But though the ants so markedly avoided the violet glass, still, as might be expected, the violet glass certainly had some effect, because if it was put over the nest alone, the ants preferred being under it to being under the plain glass only.

I then compared the violet glass with a solution of ammonio-sulphate of copper, which is very similar, though perhaps a little more violet, and arranged the depth of the fluid so as to make it as nearly as possible of the same depth of colour as the glass.

Approx. number of Ants under the	Exp. 1.	Exp. 2.	Exp. 3.	Exp. 4.	Exp. 5.	Exp. 6.
Glass............	0	0	0	2	0	2
Solution	40	80	100	80	50	70

	Exp. 7.	Exp. 8.	Exp. 9.	Exp. 10.	Total.
Glass	0	2	3	0	9
Solution	60	40	90	100	710

In another experiment with *Lasius niger* I used the dark yellow glass, dark violet glass, and a violet solution of 5 per cent. ammonio-sulphate of copper, diluted so as to be, to my eye, of exactly the same tint as the violet glass; in 8 observations the pupæ were three times under the violet solution, and 5 times under the yellow glass. I then removed the yellow glass, and in 10 more observations the pupæ were always brought under the solution.

It is interesting that the glass and the solution should affect the ants so differently, because to my eye the two were almost identical in colour. The glass, however, was more transparent than the solution.

To see whether there would be the same difference between red glass and red solution as between violet glass and violet solution, I then (Aug. 21) put over a nest of *Formica fusca* a red glass and a solution of carmine, as nearly as I could make it of the same tint. In 10 experiments, however, the ants were, generally speaking, some under the solution and some under the glass, in, moreover, as nearly as possible equal numbers.

Aug. 20.—Over a nest of *Formica fusca* containing 20 pupæ, I placed a saturated solution of bichromate of potash, a deep solution of carmine, which let through scarcely any but the red rays, and a white porcelain plate.

Observation		Bichromate of potash		Carmine		Porcelain
1. Under the bichromate of potash were		0 pupæ,	carmine	18,	porcelain	2.
2.	”	0	”	6	”	14.
3.	”	6	”	3	”	11.
4.	”	0	”	5	”	18.
5.	”	6	”	4	”	10.
6.	”	0	”	19	”	1.
7.	”	0	”	0	”	20.
8.	”	4	”	15	”	1.
9.	”	2	”	4	”	14.
10.	”	0	”	4	”	16.
11.	”	0	”	3	”	17.
Total......		18		81		124

I then put over another nest of *Formica fusca* four layers of red glass (which, when examined with the spectroscope, let through red light only), four layers of green glass (which, examined in the same way, transmitted nothing but a very little green), and a porcelain plate. Under these circumstances the ants showed no marked preference, but appeared to feel equally protected, whether they were under the red glass, the green glass, or the porcelain.

Thus, though it appears from other experiments that ants are affected by red light, still the quantity that passes through dark red glass does not seem to disturb them. I tested this again by placing over a nest containing a queen and about 10 pupæ a piece of opake porcelain, one of violet, and one of red glass, all of the same size. The result is shown below.

Observation.							
1.	Queen went under	red glass.	5	pupæ were taken	under red glass,	2	under porcelain.
2.	”	porcelain.	0	”	”	7	”
3.	”	red glass.	0	”	”	7	”
4.	”	”	6	”	”	2	”
5.	”	”	6	”	”	2	”
6.	”	”	3	”	”	7	”
7.	”	”	10	”	”	0	”
8.	”	”	4	”	”	6	”
9.	”	”	1	”	”	0	”
10.	”	porcelain.	0	”	”	10	”
11.	”	red glass.	10	”	”	0	”
12.	”	porcelain.	4	”	”	6	”
13.	”	red glass.	7	”	”	3	”
14.	”	porcelain.	4	”	”	6	”
15.	”	red glass.	4	”	”	6	”
16.	”	porcelain.	0	”	”	10	”
17.	”	red glass.	10	”	”	0	”
18.	”	”	8	”	”	2	”
19.	”	porcelain.	7	”	”	3	”
20.	”	”	1	”	”	9	”
			90			88	

Obviously, therefore, the ants showed no marked preference for the porcelain. On one, but only on one occasion (Obs. 9), most of the pupæ were carried under the violet glass, but generally it was quite neglected.

I now tried a similar experiment with two layers of yellow glass.

Obs.									
1.	Queen	went under the	porcelain.	8	pupæ	were taken under yellow,	2	under porcelain.
2.	,,	,,	,,	2	,,	,,	8	,,
3.	,,	,,	,,	8	,,	,,	2	,,
4.	,,	,,	yellow glass.	5	,,	,,	5	,,
5.	,,	,,	porcelain.	3	,,	,,	8	,,
6.	,,	,,	yellow glass.	8	,,	,,	3	,,
7.	,,	,,	porcelain.	6	,,	,,	5	,,
8.	,,	,,	,,	0	,,	,,	7	,,
9.	,,	,,	,,	0	,,	,,	10	,,
10.	,,	,,	yellow glass.	9	,,	,,	1	,,
11.	,,	,,	porcelain.	8	,,	,,	2	,,
12.	,,	,,	,,	3	,,	,,	7	,,
13.	,,	,,	yellow glass.	10	,,	,,	0	,,
14.	,,	,,	porcelain.	0	,,	,,	10	,,
15.	,,	,,	yellow glass.	10	,,	,,	0	,,
16.	,,	,,	,,	7	,,	,,	3	,,
17.	,,	,,	,,	10	,,	,,	0	,,
18.	,,	,,	porcelain.	1	,,	,,	9	,,
19.	,,	,,	,,	0	,,	,,	10	,,
				98			92	

I then put two ants on a paper bridge, the ends supported by pins, the bases of which were in water. The ants wandered backwards and forwards, endeavouring to escape. I then placed the bridge in the dark and threw the spectrum on it, so that successively the red, yellow, green, blue, and violet fell on the bridge. The ants, however, walked backwards and forwards without (perhaps from excitement) taking any notice of the colour.

I then allowed some ants (*Lasius niger*) to find some larvæ, to which they obtained access over a narrow paper bridge. When they had got used to it, I arranged so that it passed through a dark box, and threw on it the principal colours of the spectrum, namely, red, yellow, green, blue, and violet, as well as the ultra-red and ultra-violet; but the ants took no notice.

At the suggestion of Prof. Stokes, I then tried the following experiments. Mr. Spottiswoode not only most kindly placed the rich resources of his laboratory at my disposal, but he and his able assistant Mr. Ward were good enough to arrange the apparatus for me.

We tried the ants with coloured lights in a Bunsen's burner, using chloride of strontium and carbonate of lithia for red, chloride of barium for green, and chloride of sodium for yellow. The lithium gives an almost pure red, the strontium and barium give a little yellow, but so little that I do not think it would affect the ants.

The ants on which we experimented were *Formica fusca* and *F. cinerea* and *Cremastogaster scutellaris*; but it was rather too late in the season, and they were somewhat torpid.

The yellow of the soda-flame certainly affected the *Formica cinerea*, but the others seemed to take no notice of it.

The barium also affected the *F. cinerea*, but neither of the others; I could not feel sure whether it was the green or the accompanying yellow which disturbed them. The red of the lithium was not so brilliant, still the *F. cinerea* seemed to perceive it.

The strontium-flame did not seem to have any effect on the ants.

It is obvious that these facts suggest a number of interesting inferences. I must, however, repeat the observations and make others; but we may at least, I think, conclude from the preceding that:—(1) ants have the power of distinguishing colour; (2) that they are very sensitive to violet; and it would also seem (3) that their sensations of colour must be very different from those produced upon us.

As to the Longevity of Ants.

I have been much surprised at the longevity of my ants. I have still two queens of *Formica fusca** which have been with me since 1874. They must therefore now be at any rate four years old; but as they were probably a year old when I captured them, they would now be not less than five years old. As regards workers, I have some specimens of *Formica sanguinea* and *F. fusca* which M. Forel was so good as to send me from Munich in the beginning of September 1875, some *F. cinerea* which I brought back from Castellamare in Nov. 1875, and a great many belonging to various species which have been with me since 1876.

On the Butterflies in the Collection of the British Museum hitherto referred to the Genus *Euplœa* of Fabricius. By ARTHUR G. BUTLER, F.L.S., &c.

[Read February 21, 1878.]

IN the year 1866 I published a "Monograph of the Diurnal Lepidoptera belonging to the Genus *Euplœa*," in the 'Proceedings of the Zoological Society.' In this memoir I split up the group into arbitrary and, as I now see, very unnatural divisions, overlooking the fact that several natural genera existed.

* These ants are still alive, Aug. 1878.

In his paper "On the Generic Names proposed for Butterflies," Mr. Scudder regards *Danais similis* as the type of *Euplœa*, his argument being briefly as follows:—The Fabrician species are *E. plexippus*, *E. similis*, and *E. core*; *E. plexippus* is the type of *Danaida*, Latreille, and *E. core* of *Crastia*, Hübner; therefore *E. similis* must be accepted as the type of *Euplœa*.

Since no structural distinction between the green-spotted and tawny species of *Danais* has, to my knowledge, ever been pointed out, it would create hopeless confusion to accept this conclusion of Mr. Scudder's; for then we should have to call *Danais* "*Euplœa*," and sink the "*Danaida*" of Latreille (plural form of the same) as a synonym; I therefore would propose that the general usage of the Fabrician name be retained.

In Mr. Scudder's revision of the genera he frequently supersedes a name long in use by the resuscitation of a partial synonym—that is to say, he knocks over such a genus as *Euplœa* (or, at any rate, its long-accepted use) by the restoration of a name applied to two of its many species. This alteration is in such cases not a help, but a great hindrance to the advancement of science, almost as much so, indeed, as his departure from the rule of the British Association respecting the use of the terminations *idæ* and *inæ* for families and subfamilies, for the sake of adopting the long-forgotten terms *Astyci*, *Rurales*, *Candidi*, and a host of others.

For some of the genera Mr. Scudder objects to Hübner's names because of the heterogeneous character of the material associated under them by their author; whereas in the case of others (*Cithærias*, for instance) he selects the only species which ought to have been omitted by Hübner as the type, thereby retaining a generic name which, of all others, ought to be shelved, to the overthrow of a properly defined recent genus. Where such partiality is observed in the adoption or rejection of names, it is impossible altogether to follow this author.

It is my opinion, then, that *E. core* should, as hitherto, be regarded as type of the Fabrician genus, and *E. climene* (placed with it by Hübner) as type of *Crastia*.

I propose to adopt the genera *Salpinx* and *Trepsichrois* of Hübner, to fix the limits of my genus *Calliplœa*, and to add a genus for the reception of all those species the males of which have *two brands* upon the interno-median area of primaries: for this group I propose the name *Stictoplœa*. The use of the brands

on the males of *Euplœa* and *Stictoplœa* is not certainly known; they are, however, distinctly impressed upon that portion of the primaries which comes in contact with the anterior border of the secondaries and the very prominent costal vein of the same wings (between which the surface is much depressed); it is therefore possible that they are for purposes of strigillation. In the following pages I shall give a list, under each genus, of the species contained in the Museum cabinets, adding notes where necessary to the elucidation of changes in synonymy &c., but not needlessly burdening the paper with a repetition of the references contained in Mr. Kirby's 'Synonymic Catalogue.'

The first genus, *Salpinx*, is not altogether a satisfactory one; it contains two groups of species, the one group being much like an enormous form of *Calliplœa* (I refer to the *S. phænareta* group), the other having a blue or sericeous brand upon the internomedian area; in other respects the species seem nearly allied.

I propose to give the first of these groups the subgeneric title of *Macroplœa*.

SALPINX, *Hübner*.

Macroplœa, Butler.

1. S. PHÆNARETA, *Schaller*. ♂ ♀, Amboina and North Ceram. *S. unibrunnea* of Salvin should follow this species.

2. S. ELISA, *Butler*. ♂ ♀, Ceylon. (Types.)

3. S. PHŒBUS, *Butler*. ♂ ♀, Moulmein, Penang, Malacca. (Types.) *S. browni* of Salvin should be placed here and succeeded by *S. mesocala* of Vollenhoven, the female of which somewhat resembles it.

4. S. CALLITHOË, *Boisd*. ♀, New Guinea. I mistook this fine species for the female of *S. mesocala*, than which it is altogether darker; the *Euplœa callithoë* of my Monograph is an entirely distinct species.

5. S. SEMICIRCULUS, *Butler*. ♂. *Hab.* —— ? (Type.)

Salpinx, typical.

6. S. HISME, *Boisduval*. ♀, Aru. Felder redescribes this species under the name of *E. bernsteinii*.

7. S. PASITHEA, *Felder*. ♂ ♀, Amboina and Ceram. This is the *E. eunice* of my Monograph, and much like the Java species;

the *E. staintonii* of Felder is a slight variety to which one of our Amboinese examples is referable.

8. S. CONSANGUINEA, n. sp.—Allied to *S. pasithea*, but more readily compared with *E. iphianassa*; it differs from the latter in the small size of the discal series of white spots on the primaries, all, excepting the two uppermost in the male, being reduced to points, and all those of the female being of equal size: expanse 3 inches 3–5 lines. ♂ ♀, Aneiteum, New Hebrides (five examples).

9. S. GRAEFFIANA, *Herr.-Sch.* ♂, Vaté, New Hebrides. This is readily distinguished from the preceding by the pale borders to its wings.

10. S. IPHIANASSA, *Butler.* ♂ ♀, Aneiteum, New Hebrides. (Types.)

11. S. EUNICE, *Godart.* ♂ ♀, Java.

12. S. VESTIGIATA, *Butler.* ♂ ♀, Sumatra and Malacca. (♂ type.)

13. S. HOBSONII, *Butler.* ♀, Formosa. (Type.)

14. S. KADU, *Eschscholtz.* ♂ ♀, Borneo.

15. S. HEWITSONII, *Butler.* ♀, Philippines. (Type.) Rather larger than the preceding, the spots of primaries larger and bluer; two large spots on interno-median area, the lower one being very large and white-centred. This appears to differ locally from Bornean examples, and therefore I reinstate it.

16. S. VIOLA, *Butler.* ♂ ♀, Celebes. (Types.)

17. S. MNISZECHII, *Felder.* ♂ ♀, Celebes.

18. S. ELEUSINE, *Cramer.* ♂ ♀, Java.

19. S. IMITATA, *Butler.* ♂, Solomon Islands. (Type.)

20. S. FRATERNA, *Felder.* ♂, Ké Island.

21. S. ASSIMILATA, *Felder.* ♂, "Tijoor." I cannot find the locality of our example in any atlas; Felder gives Aru as the habitat of the species.

22. S. FRIGIDA, n. sp.—Allied to the preceding, but the white arched belt of primaries further from the outer margin (which is broadly brown), and fading away on the first median interspace instead of running round the outer part of the inner margin;

white outer border of secondaries narrower: expanse 3 inches 7 lines. ♂, North Ceram.

23. S. USIPETES, *Hewitson*. ♂, Aru Islands.

24. S. HYACINTHUS, *Butler*. ♂ ♀, Celebes. (Types.)

25. S. EUPATOR, *Hewitson*. ♂, Celebes.

26. S. RADAMANTHUS, *Fabricius*. ♂, Silhet; ♀, Nepal. This seems to me to be the Fabrician insect; Mr. Moore has a series of both sexes.

27. S. DIOCLETIANUS, *Fabricius*. ♂ ♀, Malacca, Penang, Singapore.

28. S. LOWII, n. sp.—Differs from the preceding in the smaller size of all its spots, the white patch of primaries distinctly excavated internally; the two spots nearest to the apex white; secondaries with only three or sometimes two short internal white streaks: expanse 3 inches 4 lines. Borneo (*Low*). Two ♂ examples. I have seen other specimens of this species, which is quite constant in its differences from the Malacca form.

29. S. ALCIDICE, *Godart*. ♂ ♀, Java. This is another well-marked local form of the *Radamanthus* group.

30. S. LORENZO, *Butler*. ♂, Solomon Islands. (Type.)

31. S. TREITSCHKII, *Boisduval*. ♂ ♀, New Ireland.

32. S. SUPERBA, *Herbst*. ♂ ♀, India, S. China. I believe the *E. ochsenheimeri* of Lucas (*nec* Moore) to be either a faded example of this species, or something very closely allied to it.

33. S. SPLENDENS, *Butler*. ♂ ♀, Nepal and Cherra Poonjee. (Type.) Felder has described this species under the name of *E. rogenhoferi*.

34. S. MARGARITA, *Butler*. ♂ ♀, Moulmein, Penang, Malacca. (Types.)

35. S. KLUGII, *Moore*. ♂ ♀, N. India.

36. S. ILLUSTRIS, n. sp.—Nearly allied to *S. klugii*, but the outer border of primaries deep chocolate-brown, not covered by the blue shot, and with the white spots upon it smaller; the discal series of spots abbreviated, not extending below the inferior discoidal interspace; the third spot in the series considerably larger: expanse 3 inches 11 lines. ♂, Silhet.

37. S. CHLOË, *Guérin*. ♂ ♀, Sumatra and Malacca.

38. S. CRASSA, *Butler*. ♂ ♀, Siam. (Types.)

39. S. ERICHSONII, *Felder*. ♂ ♀, Dukhun and Bhotan.

40. S. GAMELIA, *Hübner*. ♂ ♀, Java.

41. S. ÆGYPTUS, *Butler*. ♂ ♀, Borneo, Sumatra, Singapore. (Types.) The preceding forty-one species are, for the most part, large insects, the males of which invariably have a strongly arched inner margin to the primaries, which are frequently ornamented by an elongated depressed silky or blue spot; the secondaries invariably with a large patch of whitish or pale yellow cut by the subcostal vein.

CALLIPLŒA, Butler.

1. C. LEDERERI, *Felder*. ♂ ♀, E. India, Malacca. *C. dehaanii* seems to be allied to this species.

2. C. SERIATA, *Herr.-Sch.* ♂, Moala Island; ♀, Maré, Loyalty group.

3. C. DORYCA, n. sp.—♀. Allied to the preceding and to *C. mazares*, larger and more brilliantly blue-shot than either: wings above piceous, very dark and brilliantly shot with purplish blue; outer borders chocolate-brown, darkest on the primaries; eight white-centred lilac spots in an angular series, the three first confluent, the first and last minute, the others larger: secondaries with an angular discal series of lilacine white spots, the three nearest to apex alone distinct, decreasing in size from the costa. Wings below chocolate-brown, with a continuous discal series of white spots, each wing also with a marginal series of white dots not reaching the apex; primaries with a white subcostal point above the end of the cell; a large lilacine white oval spot near the base of the first median interspace; inner border pale sandy brown, with a large central lilacine patch. Expanse 3 inches 1 line. Dorey (*Wallace*).

I have little doubt that Dr. Felder has confounded both this and *E. mazares* with his *E. saundersii*.

4. C. MAZARES, *Moore*. ♂ ♀, Java. (Types.)

5. C. PUMILA, *Butler*. ♂ ♀, New Guinea, Waigiou. (Types.) One or two species allied to this have recently been described by Kirsch. *C. trimenii* of Felder is the same insect.

6. C. INFANTILIS, *Butler*. ♂, New Guinea. (Type.) The *Eupl. semperi* of Felder seems nearly allied to this species.

7. C. JAMESII, *Butler*. ♂ ♀, Port Moresby. (Types.)

8. C. SAUNDERSII, *Felder*. ♂, Aru Island (three males). *C. forsteri* and *C. adyte* are clearly allied to this species.

9. C. TURNERI, n. sp.—♀. Allied to the preceding, but more so to *C. tulliolus*, from which it differs in the white spotting of the primaries, only the second to the fourth of the discal spots being united to form the subapical patch (in *E. tulliolus* the fifth is included), and in the more olivaceous tint of the broad pale outer border of secondaries: expanse 2 inches 9 lines. Darnley Island (*Dr. Turner*).

10. C. TULLIOLUS, *Fabricius*. ♂ ♀, Rockingham Bay, Port Stephen, Frankland Isles, Aneiteum, and Erromango.

11. C. POLLITA, *Erichson*. ♂, Philippines. This is very closely allied to *C. tulliolus*, but the second to the sixth of the white spots are connected.

12. C. NIVEATA, *Butler*. ♂ ♀, Queensland, Cape York, Fitzroy Island. (Types.)

13. C. HYEMS, *Butler*. ♂, Timor. (Type.) The *Eupl. arisbe* of Felder is this species, and *E. hopfferi* is a nearly allied form.

14. C. DARCHIA, *M'Leay*. ♂ ♀, Australia.

15. C. PRIAPUS, *Butler*. ♂ ♀, Port Essington, New Holland. (Types.) The species of *Calliplœa* are all small; they have the inner border of the primaries in the males strongly developed and covering a large subcostal yellowish patch upon the secondaries, but without any trace of a brand on the interno-median area.

TREPSICHROIS, Hübner.

Primaries elongated, the outer margin subangulated and slightly inarched below the apex; the inner margin of the male very slightly convex, without trace of a brand, but the secondaries with a small yellowish patch in the cell at the origin of the first subcostal branch.

1. T. CLAUDIA, *Fabricius*. ♂ ♀, Java.

2. T. MULCIBER, *Cramer*. ♂ ♀, Labuan, Sarawak, Malacca.

3. T. MIDAMUS, *Linnæus.* ♂ ♀, Malacca, Penang, Sumatra, Nepal, N. India.

4. T. TISIPHONE, *Butler.* ♂, Philippines.

CRASTIA, Hübner.

Males with more acuminate primaries than in *Trepsichrois*, the inner margin much more convex; no brand on the primaries, and no yellowish spot in the cell of secondaries: females similar to *Trepsichrois* in form.

1. C. SCUDDERII, n. sp.—Near to "*C. ochsenheimeri*" of Moore, but much darker; above with a small spot above the end of the cell, a second in the cell, a third at one third the distance between the cell and the apex, two placed obliquely on the inferior discoidal and second median interspaces; a discal curved series of eight (of which the third is largest), and an irregular submarginal series of dots, white: secondaries with one or two subapical white points; costal area pale. Primaries below nearly as in the *C. ochsenheimeri* of Moore, but the spots smaller; secondaries with fewer and smaller spots, the submarginal series obsolete. Expanse 1 inch 10 lines. Borneo (*Shepherd*).

2. C. OCHSENHEIMERI, *Moore.* ♂ ♀, Java. (Types.) This is probably the *C. gyllenhalii* of Lucas; but the description of that species states at first that the spots on the primaries are blue; afterwards, in the comparative description of the female, they are called white: I therefore prefer provisionally to retain Mr. Moore's name for this Javan species, which is generically distinct from the *Eupl. ochsenheimeri* of Lucas.

3. C. MALAYICA, n. sp.—Closely allied to the preceding, but larger, considerably darker, and with the white spots much larger, both the submarginal series in the secondaries of the male complete; the female with a spot in the cell followed by three complete series: expanse 4 inches 7 lines. ♂ ♀, Malacca, Penang, Singapore.

4. C. CRATIS, *Butler.* ♂, Philippines. (Type.)

5. C. DIOCLETIA, *Hübner.* ♂ ♀, Philippines.

6. C. KINBERGI, *Wallengren.* ♀, China.

7. C. CRAMERI, *Lucas* (& *Moore*). ♂ ♀, Borneo. The description by M. Lucas answers to Moore's species.

8. C. MOOREI, *Butler*. ♀, Sumatra. (Type.)

9. C. BREMERI, *Felder*. ♂ ♀, Malacca, Sumatra, India.

10. C. EBENINA, *Butler*. ♂, Aru. (Type.) The *E. aglidice* of Boisduval seems allied to *C. ebenina*, but differs on the under surface.

11. C. LUGENS, *Butler*. ♂, New Guinea. (Type.)

12. C. FUNEREA, n. sp.—Velvety black-brown, with the costal borders and a broad external border bronzy olive-brown, crossed by a snow-white discal belt divided into spots by the nervures, angulated in primaries, twice as wide in the female as in the male, and followed (excepting at apex of primaries) by a submarginal series of white spots in couples: wings below paler and redder than above; a blue spot in each discoidal cell, followed by a series of blue spots, three or four in the primaries, and five in an angular series in the secondaries: expanse 3 inches 5 lines. ♂ ♀, Port Moresby (*Dr. Turner*). A beautiful species.

13. C. SQUALIDA, n. sp.—Nearly allied to the preceding, smaller, paler, with all the spots of the white belt well separated, of a dull creamy tint; the submarginal spots absent from the primaries, obsolescent on the secondaries; the outer margin of the primaries is also much straighter, and the discal series of spots parallel to it, and therefore not sinuous as the white belt is in *C. funerea*: expanse, ♂ 3 inches 4 lines, ♀ 2 inches 11 lines. ♂ ♀, Port Moresby (*Dr. Turner*).

If this species did not differ in shape, as well as in colour and marking, it might be regarded as a variety of *C. funerea*.

14. C. RESARTA, *Butler*. ♂ ♀, Port Moresby (*Dr. Turner*).

15. C. NOX, *Butler*. ♂, Aru. (Type.)

16. C. GOUDOTII, *Boisduval*. ♀, Madagascar.

17. C. ALECTO, *Butler*. ♂ ♀, Ceram. (Types.)

18. C. MELANCHOLICA, *Butler*. ♂, Amboina. (Type.)

19. C. CAMARALZAMAN, *Butler*. ♂, Siam. (Type.)

20. C. MODESTA, *Butler*. ♂, Siam; ♀, Moulmein. (Types.)

21. C. SEPULCHRALIS, *Butler*. ♂ ♀, Java. (Types.) *Eupl. zinkenii* of Felder is the Amboinese form of this species, with which it is confounded by its author.

22. C. CLIMENA, *Cramer*. ♂ ♀, Ceram, Amboina.

23. C. MELINA, *Godart*. ♀, Aru and Ceram. *Eupl. redtenbacheri* of Felder is identical with this species.

24. C. WALLACEI, *Felder*. ♂, Gilolo.

25. C. LAPEYROUSEI, *Boisduval*. ♂, Port Moresby. *Eupl. batesii* of Felder, from Gilolo, seems closely allied to this.

26. C. OCCULTA, *Butler*. ♂ ♀, Port Moresby. (Type.)

27. C. ÆTHIOPS, *Butler*. ♂, Waigiou. (Type.)

28. C. GRAYI, *Felder*. ♂, Aru.

29. C. CONFUSA, *Butler*. ♂, Waigiou and New Guinea. (Type.)

EUPLŒA, *Fabricius*.

The species of this genus are for the most part similar in form to those of the genus *Crastia*; but the males have a more or less strongly defined longitudinal brand on the interno-median area of the primaries.

1. E. SWAINSONII, *Godart*. ♂ ♀, Philippines. *E. donovani*, from Celebes, is allied to the above.

2. E. BELINDA, n. sp.—♀. Allied to *E. orope*, but the secondaries with pale brown external area, crossed by a discal decreasing series of white spots and a submarginal series of white dots (nearly as in *E. helcita*): expanse 2 inches 9 lines. Sumatra.

3. E. OROPE, *Boisduval*. ♂ ♀, Timor. *E. baudiniana* of Godart may perhaps be a variety of this species.

4. E. ELEUTHE, *Quoy & Gaimard*. ♀, Samoa (?), Ellice Islands.

5. E. CORINNA, *M'Leay*. ♂ ♀, New Holland. *E. angasii* from Cape York and Moreton Bay, and *E. lewinii* from N. Australia, Port Bowen, and Champion Bay, are slight varieties of this abundant species.

6. E. HELCITA, *Boisduval*. New Caledonia, Erromango, Aneiteum, Navigators' Islands. Identical with *E. montrouzieri* of Felder.

7. E. ESCHSCHOLTZII, *Felder*. Fiji. A slight local modification of the preceding species.

8. E. DISTINCTA, *Butler*. ♂ ♀, Ellice Islands (*Whitmee*).

9. E. PERRYI, *Butler*. ♂, Nieue or Savage Island. (Type.)

10. E. PROSERPINA, *Butler*. ♂ ♀, Ovalau, Vanua Levu, Fiji. (Types.)

11. E. ABJECTA, *Butler*. ♂ ♀, Philippines. (Types.)

12. E. WHITMEI, *Butler*. ♂, Lifu. (Type.) *E. boisduvalii* of Lucas seems to be an allied species.

13. E. SCHMELTZI, *Herr.-Sch.* ♂, Samoa; ♀, Upolu.

14. E. MITRA, *Moore*. ♂, Seychelles. (Type. *Hab.* —— ?

15. E. ANDAMANENSIS, *Atkinson*. ♂, Andamans.

16. E. DIANA, *Butler*. ♂, Celebes. (Type.) This is the *E. kirbyi* of Felder.

17. E. HORSFIELDII, *Felder*. ♂, Celebes. *E. leachii* of Felder is an allied species.

18. E. FELDERI, *Butler*. ♂ ♀, Hong-Kong, Sumatra. (Type.) This is the *E. lorquinii* of Felder.

19. E. FRAUENFELDI, *Felder*. ♂, Trincomalee.

20. E. AMYMONE, *Godart*. ♂ ♀, Cochin-China and Sumatra.

21. E. HÜBNERI, *Moore*. ♂, Java. (Type.)

22. E. WALLENGRENII, *Felder*. ♂ ♀, Java (*Horsfield*).

23. E. SCHERZERI, *Felder*. ♂, Java (*Horsfield*). This appears to be an immaculate form of *E. wallengrenii*; it is not congeneric with my *E. picina*.

24. E. JANUS, *Butler*. ♂ ♀, Java. (Types.)

25. E. MEGÆRA, *Butler*. ♂ ♀, Aru. (Types.)

26. E. GUÉRINII, *Felder*. ♂ ♀, Port Moresby (*Dr. Turner*).

27. E. VIOLETTA, *Butler*. ♂ ♀, Port Moresby (*Dr. Turner*). We have eight forms which make a gradation from this species to *E. dolosa*, and respecting which it is impossible, without breeding, to decide as to whether they are varieties or species; they all have females like themselves in tint and marking, but the distinctions between each two of these forms are less than are usually to be found in allied species occupying the same district. I believe one or two of them are distinct; but until I have seen more examples it would be mischievous to name any of them without giving figures of the whole.

28. E. DOLOSA, *Butler*. ♂ ♀, Port Moresby (*Dr. Turner*).

29. E. ANTHRACINA, *Butler*. ♂, Amboina. (Type.)

30. E. DUPONCHELII, *Boisduval*. ♂, Ceram. Close to the preceding, perhaps not distinct.

31. E. PIERRETII, *Felder*. ♂, Waigiou; ♀, Port Moresby.

32. E. MOROSA, *Butler*. ♂ ♀, Sumatra(?) and Gilolo. (Types.) This is *E. dalmanii* of Felder.

33. E. TORVINA, *Butler*. ♂ ♀, Aneiteum, Lifu. (Types.)

34. E. PAYKULLEI, *Butler*. ♂ ♀, Vaté, Aneiteum, Mota Island. (Types.)

35. E. BRENCHLEYI, *Butler*. ♂ ♀, Solomon Islands. (Types.) *E. vicina* of Felder is intermediate in character between this species and the next.

36. E. EURYPON, *Hewitson*. ♂, Ké Island.

37. E. GODARTII, *Lucas*. ♂ ♀, Philippines and Siam. This is *E. siamensis* of Felder.

38. E. COREOIDES, *Moore*. ♀, Ceylon.

39. E. CORE, *Cramer*. ♂ ♀, N. India, Landoor.

40. E. VERMICULATA, *Butler*. ♂ ♀, N. India, N. Bengal.

41. E. EYNDHOVII, *Felder*. ♂ ♀, Java (*Horsfield*).

42. E. ALCATHOË, *Godart*. ♂ ♀, Silhet, N. India. Felder has redescribed this as *E. doubledayi* because of the incorrectness of Godart's locality; *E. geyeri*, from Java, is intermediate in character between *E. alcathoë* and *E. pinwillii*.

43. E. PINWILLII, *Butler*. ♂ ♀, Malacca. (Types.)

44. E. MÉNÉTRIÉSII, *Felder*. ♂ ♀, Borneo, Malacca, India.

45. E. DEIONE, *Westwood*. ♂ ♀, Darjeeling, Silhet. Felder has described the female under the name of *E. poeyi*.

STICTOPLŒA, *Butler*.

Males for the most part with straight inner margin like the females, always with two well-defined sericeous brands on the interno-median area, and placed one above the other. Type *S. gloriosa*.

1. S. GLORIOSA, *Butler*. ♂, Celebes. (Type.) This is described by Felder as *E. schlegelii*, and by Vollenhoven as *E. superba*.

2. S. swinhoei, *Wallace*. ♂ ♀, Formosa.

3. S. lætifica, *Butler*. ♂ ♀, Philippines. (Types.)

4. S. grotei, *Felder*. ♂ ♀, Malacca. *Eupl. harrisii* of Felder is closely allied to this species.

5. S. hopei, *Felder*. ♂, Silhet.

6. S. microsticta, n. sp.—Primaries like those of *S. hopei*, excepting that they are larger, all the spots are considerably smaller, and the purple shot is less vivid; secondaries with only the three first of the discal series of white spots: expanse 4 inches 2 lines. *Hab.* —— ? (From the Banksian Cabinet.)

7. S. binotata, n. sp.—♂ ♀. Primaries quite as in *S. hopei*; secondaries with only two white subapical points; all the other spots obsolete: expanse 4 inches 2 lines. Silhet, Darjeeling, North India, E. India, Borneo.

This is the *Eupl. callithoë* of my Monograph, but not of Boisduval.

8. S. lankana, *Moore*. ♂ ♀, Ceylon. *S. consimilis* and *montana* of Felder are allied to this species.

9. S. picina, *Butler*. ♂, Sumatra. (Type.)

10. S. inæqualis, n. sp.—♂. Nearly allied to *S. picina*, but much smaller, the primaries above with the upper longitudinal sericeous brand narrower and much shorter than the lower brand; secondaries blacker, with the disco-submarginal area much paler, forming an internally diffused belt; wings below with all the bluish-white spots much smaller: expanse 3 inches 11 lines. Amboina.

11. S. inconspicua, n. sp.—♂. Wings above dull black; primaries with the central three fifths of the costal border, the external border, external angle and outer third of internal border chocolate-brown, diffused internally; the two sericeous streaks well developed, the upper one narrower and slightly shorter than the lower: secondaries with the costal border broadly sericeous white; subcostal and interno-median areas chocolate-brown, diffused; external area broadly reddish brown, diffused internally. Wings below bronzy reddish brown, blackish in the centre: primaries with the internal border greyish sericeous, terminating externally, near the external angle, in a whitish patch; a small spot in the cell and two on the median interspaces bluish white:

secondaries with a spot in the cell, and five in an angular series beyond it, bluish white. Expanse 3 inches 7 lines. Sumatra.

12. S. IMMACULATA, n. sp.—♂ ♀. Nearly allied to *S. mœsta*, but altogether darker, the male without the apical or submarginal blue spots, and the female without the white spots on the upper surface of the primaries; blue spots below small, but similar: expanse, ♂ 3 inches 3–4 lines, ♀ 3 inches 1 line. Port Moresby (*Dr. Turner*).

Possibly a variety of *S. mœsta*, approaching the preceding species.

13. S. MŒSTA, *Butler*. ♂, Dorey; ♂ ♀, Port Moresby. (Type.)

14. S. DOLESCHALII, *Felder*. ♂ ♀, Port Moresby.

15. S. TRISTIS, *Butler*. ♂, Aneiteum, New Hebrides. (Type.)

16. S. PALLA, *Butler*. ♂, Aru. (Type.)

17. S. SYLVESTER, *Fabricius*. ♂ ♀, Port M'Quarie, N. Australia, Cape York.

18. S. PELOR, *Doubleday*. ♂ ♀, Australia, New Holland. (Types.)

19. S. ?EUPHON, *Fabricius*. ♀, Mauritius. We have five examples of this species, one of which appears to be a male; if so, this species will come into *Crastia*, near *C. goudotii*, since none of our specimens have a trace of any band on the primaries. I cannot decide this point without fresh examples; ours are old, and the body of the doubtful individual seems to be broken: therefore, since the pattern agrees with the Australian group, it may provisionally be retained in *Stictoplœa*.

On the Development of *Filaria sanguinis hominis*, and on the Mosquito considered as a Nurse*. By PATRICK MANSON, M.D. (Communicated by Dr. COBBOLD, F.R.S., F.L.S.)

[Read March 7, 1878.]

DEVELOPMENT cannot progress far in the Host containing the Parent Worm.—Fortunately it is an almost universal law, in the history of the more dangerous kinds of Entozoa, that the egg or embryo must escape from the host inhabited by the parent worm before much progress can be made in development. Were it possible for animals so prolific as *Filaria immitis* of the dog, or *Filaria sanguinis* of man, to be born and matured and to reproduce their kind again in an individual host, the latter would certainly be overwhelmed by the first swarm of embryos escaping into the blood, as soon as they had made any progress in growth. If, for example, the brood of embryo *Filariæ*, at any one time free in the blood of a dog moderately well charged with them, were to begin growing before they had each attained a hundredth part of the size of the mature *Filaria*, their aggregate volume would occupy a bulk many times greater than the dog itself. I have calculated that in the blood of certain dogs and men there exists at any given moment more than two millions of embryos. Now the individuals of such a swarm could never attain any thing approaching the size of the mature worm without certainly involving the death of the host. The death of the host would imply the death of the parasite before a second generation of *Filariæ* could be born, and this, of course, entails the extermination of the species; for in such an arrangement reproduction would be equivalent to the death of both parent and offspring, an anomaly impossible in nature.

The Embryo must escape from the original Host.—It follows therefore that the embryo, in order to continue its development and keep its species from extermination, must escape from the first host in some way. After accomplishing this it either lives an independent existence for a time, during which it is provided with organs for growth not possessed by it hitherto; or it is swallowed by another animal which treats it as a nursling for such time as is necessary to fit it with an alimentary system. The former arrangement obtains in the *Filariæ* inhabiting the

* [Throughout this memoir Dr. Manson employs the term "nurse" in the same sense as that in which helminthologists use the term "intermediate host." —T. S. COBBOLD.]

intestinal canal, the *Lumbricus* and thread-worm; the latter is followed by the several species of tapeworm, and also by other kinds of Entozoa.

I find that in cases where embryo *Filariæ* are not in great abundance in the blood, we may infer that there are only one or two parent worms; they often disappear completely for a time, to reappear after the lapse of a few days or weeks. From this circumstance I infer—1st, that reproduction is of an intermitting and not of a continuous character; and, 2ndly, that the embryos, after a certain time, are either disintegrated in the blood or are voided in the excretions. The latter does occur, I know from personal investigation, in the urine; and we have Dr. Lewis's testimony that he has found the animals in the tears. In this way they may have an opportunity of continuing development either free (as in the case of the *Lumbricus*) in the media into which the excretions are voided, or in the body of another animal which has intentionally or accidentally fed on these (as in the case of the tapeworms). Man, in his turn, may then swallow this hypothetic animal or other thing containing the embryo suitably perfected, and so complete the circle. This is the history of many Entozoa; but I have evidence to adduce that, if it be one way in which *F. sanguinis hominis* is nursed, it is not the only way, and therefore probably not the way at all.

The Mosquito found to be the Nurse.—It occurred to me that, as the first step in the history of the hæmatozoon was in the blood, the next might happen in an animal who fed on that fluid. To test this idea I procured mosquitos that had fed on the patient Hinlo's blood (Case No. 46, published in 'Med. Times & Gaz.' for March), and, examining the expressed contents of their abdomens from day to day with the microscope, I found that my idea was correct, and that the hæmatozoon which entered the mosquito as a simple structureless animal, left it, after passing through a series of highly interesting metamorphoses, much increased in size, possessing an alimentary canal, and being otherwise suited for an independent existence.

History of the Mosquito after feeding on Human blood.—I may mention that my observations have been made exclusively on the females of one species of mosquito. I have never, in many hundreds of specimens, met with a male insect charged with blood. This is explained by the arrangement of the appendages and proboscis of the male mosquito, which prevents it from penetrating

the skin. As the male is provided with a complete alimentary apparatus, it is presumed that he feeds on the juices and exudations of plants and fruits. There are two species of mosquito found during the summer here: one quite a large insect about half an inch long, with a black thorax and black-and-white banded abdomen; the other about half that size and of a dingy brown colour. The former is rare comparatively; the latter is very common, and is the insect my remarks apply to. After a mosquito has filled itself with blood (which it can do, if not disturbed, in about two minutes), it is evidently much embarrassed by the weight of its distended abdomen, so that it no longer can wheel about in the air. It accordingly attaches itself to some surface, if possible near stagnant water, where it remains in a comparatively torpid condition, digesting the blood, excreting yellow gamboge-looking fæces, and maturing its ova. In the course of from three to five days these processes are completed, and the insect now betakes itself to the water, where the eggs are deposited, and on the surface of which they float in a dark-brown mass, looking like a flake of soot. The eggs do not take long to hatch (they are beautifully shaped objects, like an Etruscan vase); and the embryo emerges by forcing open a sort of lid placed at the broad end of the shell. The larvæ now escape into the water, where they swim about and feed, and become the "jumpers" we are familiar with, found in every stagnant pool.

If the contents of the abdomen are examined before the mosquito has fed, or after the food has been absorbed, the following parts can easily be distinguished:—two ovisacs containing from sixty to a hundred ova, two large glandular masses (intestine and œsophagus), and a very delicate transparent fibrous bag, the stomach. If the blood contained in the dilated stomach is examined soon after ingestion, the blood-corpuscles are seen quite distinct in outline, and behaving very much as when drawn in the ordinary way; but changes rapidly occur. First, the corpuscles lose their distinctness in outline, then crystals of hæmatin appear; corpuscles and crystals give place to large oil-globules, and the mass is deprived of its fluidity, and before the eggs are deposited all colouring-matter disappears; the white material is absorbed or expelled, and by the time the eggs are deposited the stomach is quite empty but for the embryo *Filariæ* it may contain.

How to procure Mosquitos containing embryo Filariæ.—It may be useful to those who wish to repeat and test my observations

to know the plan I found most successful in procuring *Filaria*-bearing mosquitos, and how their bodies were afterwards treated for microscopic observation. Such details may appear frivolous and unimportant; but by following them the observer will be spared disappointment, and economize his time and patience.

I persuaded a Chinaman, in whose blood I had already ascertained that *Filariæ* abounded, to sleep in what is known as a mosquito-house, in a room where mosquitos were plentiful. After he had gone to bed a light was placed beside him, and the door of the mosquito-house kept open for half an hour. In this way many mosquitos entered the "house;" the light was then put out, and the door closed. Next morning the walls of the "house" were covered with an abundant supply of insects with abdomens thoroughly distended. They were then caught below a wineglass, paralyzed by means of a whiff of tobacco-smoke, and transferred to small phials, into some of which a little water had been poured. A cover providing for ventilation was then placed over the mouth of the phial. The effect of the tobacco-smoke, if it has not been applied too long, is very evanescent, and seems to have no prejudicial influence on the posture of the mosquito. From the phials they may be removed from time to time, as required, by again paralyzing with tobacco and seizing them by the thorax with a fine pincers. The abdomen is then torn off, placed on a glass slide, and a small cylinder, such as a thin penholder, rolled over it from the anus towards the severed thoracic attachment. In this way the contents are safely and efficiently expressed, and observation is not interfered with by the almost opaque integument. If the contents are white and dry a little water should be added and mixed carefully with the mass, so as to allow of the easy separation of the two large ovisacs. These can be removed in this way by the needle, and transferred to another slide for separate examination. A thin covering-glass should be placed over the residue, which will be found to contain the *Filariæ* either within the walls of the stomach, or, if these have been ruptured by too rough manipulation, floating in the surrounding water.

Large proportion of Filariæ *ingested by the Mosquito.*—The blood in the stomach of a mosquito that has fed on a *Filaria*-infested man usually contains a much larger proportion of *Filariæ* than does an equal quantity of blood obtained from the same man in the usual way by pricking the finger. Thus six small slides,

equivalent to about one drop of blood from the man on whom most of my observations were made, would contain from ten to thirty Hæmatozoa; whereas the blood drawn by a single mosquito, about as much as would fill one slide only, contained from twenty to thirty as a rule, and sometimes many more. One slide, in which I had the curiosity to count them, had upwards of a hundred and twenty specimens. From this it would appear that the mosquito has the faculty of selecting the embryo *Filariæ*; and in this strange circumstance we have an additional reason for concluding that this insect is the natural nurse of the parasite.

All Embryos do not attain maturity.—By far the greater number die and are disintegrated, or are expelled in the fæces undeveloped. At the end of the third, fourth, or fifth day, when the stomach is quite empty as far as food is concerned, and an embryo could not easily be overlooked, only from two to six are found in the same or slightly different stages of the metamorphosis, which I will now attempt to describe.

The Metamorphosis of the Embryo.—The embryo for a short time after entering the stomach of the mosquito retains all the appearances and habits which characterized it when in the human body; that is, it is a long snake-like animal, having a perfectly transparent structureless body enclosed in a delicate and, for the most part, closely applied tube, within which it shortens and extends itself, giving rise, from the collapse of the tube when the body is retracted at either end, to the appearance of a lash at the head and tail. In a very few hours changes commence. The tube first separates from the body by an appreciable interval, giving the appearance of a distinct double outline, and the body itself becomes covered with a delicate but distinct and closely set transverse striation. Oral movements are now very evident, not that they did not exist before, but because the slight increase of shading from the striation renders them more apparent. The indication of a viscus seen in some specimens vanishes at this stage. Presently the tube or sheath is either digested by the gastric juices of the mosquito, or it is cast off as a snake does its skin, and the animal swims about naked, and without any trace of a head- or tail-lash. The striation becomes very marked; but gradually as the blood thickens, and the movements of the embryo become in consequence less vigorous, these markings completely disappear, giving place to a peculiar spotted appearance. Each spot is dark or luminous, according to the focusing of the

microscope, and probably depends on some oily material now collecting in the body of the animal.

This concludes the first stage of the metamorphosis, and has taken about thirty-six hours to complete. During all this time the original proportions of the animal have been preserved and vigorous movement maintained. Now, however, it enters on a sort of chrysalis condition, during which nearly all movement is suspended, and the outline and dimensions very much altered. Hitherto the body was long and of graceful contour, but now it becomes shorter and broader, the extreme tail alone not participating in the change. The large spots in the body disappear, gradually giving place to what seems to be a fluid holding numerous minute particles in suspension. I have once or twice detected to-and-fro movements in these. The tail continues to be flexed and extended vigorously, but only at long intervals, whilst all oral movements cease. By the end of the third day the animal has become much shorter and broader, the small terminal portion of the tail still retaining its original dimensions, and appearing to spring abruptly from the end of the sausage-shaped body. Large cells occupy the previously homogeneous-looking body, and sometimes something like a double outline can be traced. Indications of a mouth present themselves; and if a little pressure is applied to the covering-glass, granular matter and cell-like bodies escape from an orifice placed a little in advance of the tail. The animal now begins to increase in length, and in some specimens to diminish in breadth, the growth seeming to be principally in the oral end of the body. The structure of the mouth is sometimes very evident; it is four-lipped, the lips being either open or pursed up. From the mouth a delicate line can be distinctly traced, passing through the whole length of the body to the opening already referred to as existing near the caudal extremity. Feeble movement may still sometimes be detected in the caudal appendix; but when the now growing body has attained a certain length the tail gradually disappears.

After this point, specimens of the *Filaria* in its third and last stage are difficult to procure. Most mosquitos die about the fourth or fifth day after feeding; and if their bodies, which fall into the water, are examined, they are soft and sodden and without *Filariæ*, these having either decomposed or escaped. Sometimes, however, ovulation does not proceed rapidly, and the mosquito survives to the fifth or sixth day; or perhaps death may not occur, as it usually does, soon after the eggs have been laid,

and the insect may survive this operation for two or three days. In such the last stage of the metamorphosis can be studied: four to six days seem necessary for its completion. Out of hundreds of mosquitos watched, I have been successful in finding *Filariæ* in this last stage in four instances only. In one of these there was quite a number of embryos in regular gradation, from the passive chrysalis up to the mature and very active embryo, so that there can be no doubt of the relationship of the latter to the former, though their appearances differ so much. Owing to the small number of specimens I have examined, I am not quite certain about the details of this stage of the metamorphosis. As far as I can make out, the body gradually elongates from the hundredth to the fortieth or thirtieth of an inch, and when mature it measures fully a fifteenth of an inch in length by the five hundredth of an inch in breadth.

When at the above stage large cells occupy the interior; but as development advances these become reduced in size, and accumulate round the dark line I have already mentioned as running from the mouth to the caudal extremity. In this way an alimentary tube is fashioned, and the peculiar and characteristic valve-like terminatiom of the œsophagus in the intestine, seen in the *Filariæ*, is developed. The mouth may now be seen open and funnel-shaped, and the tail is reduced to a mere stump. Movements, first of a swaying-to-and-fro character, but afterwards brisker, now begin. The body gradually elongates and becomes perhaps slightly thinner; all cellular appearance vanishes, and, owing to the increasing transparency of the tissues, the details can no longer be made out. A vessel of some sort is seen in the centre running nearly the whole length of the body, and opening close to one extremity; this extremity is slightly tapered, and is crowned with three, or perhaps four, papillæ; but whether this is the head or tail, and whether the vessel opening near it is the alimentary canal or vagina, I cannot say; the other extremity is also slightly tapered, but has no papillæ. There can be no doubt which is mouth and which tail, but the intermediate steps I have failed to trace satisfactorily. There is a stage between these two in which the mouth is closed, and the œsophagus can be seen running from it. If the body is compressed, that tube can be forced through the skin and distinctly seen; but about that time the tissues become so transparent that their exact relations cannot be made out.

I cannot say if the three or four papillæ round one extremity

of the developed embryo constitute the perfected boring-apparatus of the worm, or if it is the boring-apparatus at all; but comparing this with what is found in other species of the same genus, I think it very probable that it either is or will become the piercing-apparatus. Some time ago I operated on an Australian horse for this worm, and had the satisfaction of finding the parasite not very much injured after removal: it was an unimpregnated female possessing all the typical structures of the *Filariæ*. Its head was armed with a five- or six-toothed saw, the teeth arranged, like those in some kinds of old-fashioned trephines, in a circle round the mouth. I removed a worm from the same eye of the same horse about three or four weeks previously; the cornea had healed, and the cloudiness cleared up before the second worm appeared. I infer from this, from the very perfect boring-apparatus, and from the female being unimpregnated, that the eye is not the resting- or breeding-place of the *Filaria* found in it, but that it is sometimes accidentally entered by the worm on its travels in search of the suitable spot. From the fact that one worm succeeded the other I infer that the sexes are brought together in this way (as in the case of *Filaria sanguinolenta* of the dog): when a wandering worm comes across the tract of another, it follows it up; thus several may be found together at the end of the burrow.

Probably, then, these papillæ are the boring-apparatus to be used in penetrating the tissues of man and escaping from the mosquito. At this (presumably the final) stage of the *Filaria's* existence in the mosquito it becomes endowed with marvellous power and activity. It rushes about the field, forcing obstacles aside, moving indifferently at either end, and appears quite at home, and in no way inconvenienced by the water in which it has just been immersed. This formidable-looking animal is undoubtedly the *Filaria sanguinis hominis* equipped for independent life and ready to quit its nurse the mosquito.

Future history of the Filaria.—There can be little doubt as to the subsequent history of the *Filaria*, or that, escaping into the water in which the mosquito died, it is through the medium of this fluid brought into contact with the tissues of man, and that, either piercing the integuments or, what is more probable, being swallowed, it works its way through the alimentary canal to its final resting place. Arrived there, its development is perfected, fecundation is effected, and finally the embryo *Filariæ* we meet with in the blood are discharged in successive swarms and in countless numbers. In this way the genetic cycle is completed.

Revision of the *Hippidea*. By EDWARD J. MIERS, F.L.S., F.Z.S., Assistant in the Zoological Department of the British Museum.

[Read November 1, 1877.]

(PLATE V.)

Introductory Remarks.—The determination of the different species of this small and peculiar group of Anomurous Crustacea, and their identification with the brief descriptions of the earlier authors, are often very difficult. Where the type specimens no longer exist, it must of necessity remain uncertain what species were known to Linnæus and Fabricius. But three or four species are mentioned by Lamarck and Latreille; and only five are described by M. Milne-Edwards in the second volume of the 'Histoire Naturelle des Crustacés' (1837). In the twenty years following the publication of that work the number of species was more than quadrupled, as we find that Stimpson, in 1858, in the preliminary Report on the Crustacea collected by the United States Expedition to the North Pacific, enumerates (but does not describe) 23 species, contained in 6 genera; and since the publication of his list several additional species have been described. In the present revision of the group I have endeavoured, as far as the state of our knowledge and the materials afforded by the extensive collection of the British Museum will permit, to determine the geographical range and the extent of individual variation in the several species, and to indicate reliable characters by which they may be distinguished; but as several species are either *desiderata* or insufficiently represented in the national collection, there yet remain several points requiring further elucidation.

Three new species are described; but as several of those previously recorded are reduced to the rank of synonyma, the total number is only 22.

It may be desirable to present a brief summary of the views held by the different authors upon the classification and affinities of the *Hippidea*, beginning with Latreille, who, by his researches, may be considered to have laid the foundation of the natural arrangement of the Crustacea. By this author (Gen. Crust. et Ins. i. p. 44, 1806) the genera *Remipes*, *Hippa*, and *Albunea* were arranged in the family *Paguriens* of the tribe *Macroures*; but he subsequently (Cuvier R. A. ed. 1, iii. p. 27, 1817) constituted a distinct section, *Anomaux*, to contain these genera, together with the *Paguridæ*, *Porcellanidæ*, and *Galatheidæ*. Lamarck (Hist.

Nat. Animaux sans Vert. v. p. 218, 1818), observing the external relationship of the *Hippidæ* with *Ranina*, arranged them with the latter genus in a distinct section of the family, characterized by the lamellated terminal joints of the legs.

M. H. Milne-Edwards (Hist. Nat. Crust. ii. p. 167, 1837) considered the *Hippiens* a distinct tribe of the family *Ptérygures* of his *Crustacés Anomoures*, but regarded them as allied to the *Raninidæ* (p. 198).

De Haan ("Crustacea," in 'Fauna Japonica,' dec. vi. p. 195, 1849) retains in a somewhat wider sense the division *Anomala* of Latreille, in which he includes the *Hippidea*, recognizing (p. 136) their relationship to the *Raninidæ* in external appearance and the form of the legs, from which, however, he points out they are widely separated in the form of the pterygostomian regions, number of the branchiæ, and characters of the sternum and postabdomen.

By Dana (Crustacea in U.S. Explor. Exped. xiii. pp. 51 & 402, 1852) a very different view is taken of the affinities of these animals. This author traces with great care and accurate knowledge the relations of the different groups of Anomura with the higher Brachyural types, of which they are severally degraded forms, showing that they may, with equal propriety, be classified (*a*) as in a linear descending series they deviate from the Brachyural to the Macrural type, or (*b*) according to their respective natural affinities with the higher Brachyural subtribes. In the former system the *Hippidea* are ranked by him with the *Porcellanidea*, as constituting the second section, *Anomoura media*, of the tribe *Anomoura*; in the latter they are classed as *Anomoura Corystidica*, immediately beneath the *Corystoidea*, which latter are undoubtedly *Cancroid* Crustacea. With all deference to the opinion of the distinguished American naturalist, I must regard the older view of their affinities as the more correct.

Although in their elongated carapace and antennæ the *Hippidea* have a considerable resemblance to certain of the *Corystoidea*, as will be seen, *e. g.*, by comparing the Chilian *Blepharopoda spinimana* and *Pseudocorystes sicarius*, I believe their true affinities are with the Oxystomatous Brachyura, through the *Raninidæ*. They resemble these latter in their narrow and elongated form, natatorial legs, and, in the case of the *Albuneidæ*, in the high and laterally compressed hands of the anterior legs, which altogether resemble those of the Oxystomatous *Calappa* and allied genera. On account of the imperfect definition of the buccal cavity, it is

not easy to trace any resemblance either to the *Cancroidea* or to the *Oxystomata* in the form of the mouth and oral appendages. There exists, however, an important characteristic, and one, I believe, not hitherto noted, in the form of the terminal lobe of the exognath of the first pair of maxillipedes, which in the *Hippidea* is elongated and narrow, as in the *Oxystomata*, where it is usually applied to the opening of the efferent branchial channel. In the *Cancroidea* and *Oxyrhyncha* this joint is more or less obtriangular, short, and truncated at its distal extremity.

Stimpson, in the Report already referred to (Proc. Ac. Nat. Sci. Philad. p. 229, 1858), places the *Hippidea* in the second section, *Schizosomi*, of the Anomura. He establishes the two very distinct and natural families, *Hippidæ* and *Albuneidæ*, gives diagnoses of the known genera, and adds two, previously unrecorded, to the list*.

Geographical Distribution.—The *Hippidea* inhabit all the warmer temperate and tropical seas of the globe. *Remipes testudinarius*, one of the most variable, is also the most widely distributed species, occurring throughout the whole Indo-Pacific region, from the east coast of Africa, along the southern and south-eastern coast of Asia, in Australia, through the islands of the Pacific, to the Galapagos and Cape St. Lucas in California. Another species, *R. scutellatus*, is found on both the eastern and western shores of the Atlantic Ocean. The majority of the species of the family appear, however, to be somewhat restricted in their range. Those belonging to the family *Albuneidæ* are, with two exceptions, restricted to the American continent, where these Crustacea are especially abundant. The only species at present certainly known to inhabit the seas of Europe is *Albunea guerinii* from the Mediterranean.

List of the Species of Hippidea.

Fam. HIPPIDÆ.

REMIPES.

Names of the Species.	*Geographical Range.*
1. *R. testudinarius*, Latr.	Whole Indo-Pacific region.
,, var. *denticulatifrons*.	,,
2. *R. scutellatus* (Fabr.).	Florida, West Indies, West coast of Africa, Cape-Verd Islands, Ascension Island.

* Dr. Claus ('Untersuch. Crust. Syst.' pp. 59–61, Wien 1876) rejects the suborder Anomura, and refers the *Hippidea* to the Brachyura on account of what is known of their development. I regret that I have not yet had an opportunity of studying this important work.

Names of the Species.	*Geographical Range.*
3. *R. strigillatus*, Stimpson.	California.
4. *R. truncatifrons*, n. sp.	China.
MASTIGOCHIRUS.	
1. *M. gracilis*, Stm.	China.
2. *M. quadrilobatus*, n. sp.	Philippines.
HIPPA.	
1. *H. emerita* (Linn.).	Eastern coast of America (Cape Cod to Brazil).
2. *H. analoga*, Stm.	Western coast of America (California to Chili).
3. *H. asiatica*, M.-Edw.	Indian Ocean, Indo-Malayan archipelago.
Fam. ALBUNEIDÆ.	
ALBUNEA.	
1. *A. symnista* (Linn.).	Indian Ocean, Indo-Malayan archipelago.
2. *A. guerinii*, Lucas.	Gulf of Algiers.
3. *A. microps*, White, MS.	Sooloo Island.
4. *A. gibbesii*, Stimpson.	South-east coast of United States.
5. *A. oxyophthalma*, Leach (ined.).	West Indies, Cayenne, Brazil.
6. *A. lucasii*, Saussure.	Mazatlan.
7. *A. speciosa*, Dana.	Sandwich Islands.
LEPIDOPS.	
1. *L. scutellata* (Desm.).	Peru ? St. Thomas.
2. *L. venusta*, Stm.	West Indies (St. Thomas).
3. *L. myops*, Stm.	California (Cape St. Lucas).
BLEPHAROPODA.	
1. *B. spinimana* (Philippi.).	Chili.
2. *B. occidentalis*, Randall.	California.
3. *B. spinosa*, M.-Edw. and Lucas.	Peru.

As to Habits.—Until quite recently but little was known respecting the life-history and habits of the *Hippidea*; but Mr. S. I. Smith has, in his most interesting and valuable memoir on the early stages of *Hippa talpoidea* (Trans. Connect. Acad. iii. 1877), furnished a fully detailed account of the development of the common species of the Eastern shores of the United States. He states, with regard to its habits, that this animal is far more abundant on the sandy coasts of the Southern United States, and gives reasons for believing that the northern range of this, as of

many other southern species, is restricted by the extreme cold of the winters *.

He states, moreover, that *H. talpoidea* lives gregariously, burrowing in the loose and changing sands at or very near low-water mark, but that it is occasionally found swimming about in pools left by the tide, and when undisturbed sometimes comes out and swims in the same way along the shore, although probably never venturing far from the bottom.

It may be noted that Dana found his specimens of *R. hirtipes* swimming along the sandy bottom in shallow waters, near the shores of a small island off Soung, the principal harbour of the Sooloo Islands. Occasionally, however, these animals are collected at greater depths. Thus Lucas collected his specimens of *Albunea guerinii* at depths of 16–21 fathoms in the Gulf of Algiers; and *Mastigochirus gracilis*, Stimpson, was collected on a shelly bottom at a depth of 20 fathoms, at the island of Ousima. So also specimens of the rare *Blepharopoda spinimana* in the British-Museum collection were obtained by fishermen in deep water in the Bay of Valparaiso.

Fam. Hippidæ.

Hippidæ, *Stimpson, Proc. Ac. Nat. Sci. Phil.* p. 229 (1858).

Anterior legs not subcheliform. Antennæ with the accessory joint minute or obsolete. Third maxillipedes suboperculiform, the third joint greatly enlarged and without an exognath; last tail-segment greatly elongated, lanceolate, and acute at the extremity.

Remipes.

Remipes, *Latr. Gen. Crust. et Ins.* p. 45 (1806); *M.-Edw. Hist. Nat. Crust.* ii. p. 204 (1837); *Stimpson, Proc. Ac. Nat. Sci. Phil.* p. 229 (1803).

Antennules of moderate length. Antennæ very short. Third maxillipedes with the last joint somewhat unguiform. First legs elongated, subcylindrical, robust; the last joint not annulated, styliform, similar to the preceding.

Remipes testudinarius. Pl. V. fig. 1.

? Hippa adactyla, *Fabr. Ent. Syst.* ii. p. 474 (1793), *Suppl.* p. 370 (1798); *Latr. Hist. Nat. Crust.* vi. p. 176 (1803).

* The advance northwards of species common to the east coast of North America is probably checked by the cold Arctic current which impinges on the shores of the United States and flows southwards *between* the coast and the warm waters of the Gulf Stream ?—Editor.

Cancer emeritus, *Herbst, Naturg. Krabben u. Krebse*, ii. p. 8, pl. xxii. fig. 4 (1796), *nec Linn.*?

Remipes testudinarius, *Latr. Gen. Crust. et Ins.* i. p. 45 (1806); *Lam. Hist. Anim. sans Vert.* v. p. 223 (1818); *Desm. Consid. Crust.* p. 175, pl xxix. fig. 1 (1825); *M.-Edw. Hist. Nat. Crust.* ii. p. 406, pl. xxi. figs. 14–20 (1837); *Crust. in Cuvier R. A.* (ed. 3), *Atlas*, pl. xlii. fig. 1; *Guérin-Ménev. Icon. R. A. Crust.* pl. xv. fig. 3; *Heller, Reise der Novara, Crust.* p. 72 (1865); *Hilgendorf, Crust. in Van der Decken's Reisen in Ost-Afrika*, iii. p. 94 (1869).

Remipes marmoratus, *White, List Crust. Brit. Mus.* p. 58 (1847), sine descr.

Remipes pacificus, *Dana, U.S. Expl. Exp.* xiii. *Crust.* i. p. 407, pl. xxv. fig. 7 (1852); *Stimpson, Ann. Lyc. Nat. Hist. New York*, vii. p. 241 (1862); *Miers, P. Z. S.* (1877) p. 74.

Remipes hirtipes, *Dana, l. c.* p. 408, pl. xxv. fig. 8 (1852).

Remipes marmoratus, *Jacq. et Lucas, Crust. in Voy. Pôle Sud, Zool.* iii. p. 97, pl. viii. figs. 22–26 (1853); *Miers, Cat. New-Zeal. Crust.* p. 59 (1876).

Remipes pictus, *Heller, Crust. Rothen Meeres, in Sitzungsb. Ak. Wiss. Wien*, xliv. i. p. 243 (1862).

Remipes ovalis, *A. M.-Edw. Faune Carcinol. in Maillard, Ile Réunion*, ii. *Annexe F*, p. 12, pl. xvii. fig. 5 (1863).

Moderately convex, the carapace marked with numerous fine interrupted transverse lines, postfrontal sinus usually distinct. Frontal lobes moderately prominent, obtuse, and rounded, the lateral lobes (in the typical form) scarcely projecting beyond the median ones. Sides of the carapace with a series of shallow pits bordered with tufts or lines of short hairs, forming a linear submarginal striated area. Eye-peduncles slender, and usually extending a little beyond the end of the basal joint of the antennules, which, like the antennæ, are short and clothed with longish hairs. Anterior legs elongated, and clothed with rather long hairs, which are densest on the inner margins, and show a tendency to disposition in oblique series on the upper and outer margins of the last two joints; the last joint is similar to the preceding, and tapers somewhat to its extremity, which is clothed with long hair. The second, third, and fourth pairs of legs are robust; the terminal joint of the second and third pairs but slightly falcate, its distal half short, broad, and obtusely rounded at the extremity; that of the fourth pair narrow and straight. Rami of the appendages of the penultimate postabdominal segment ovate and unequal, the inner the larger. Terminal segment elongated, oblong-lanceolate.

Hab. Australian Seas (*Coll. Mus. Paris, Brit.*); Red Sea (*Heller*); Mauritius (*Coll. Mus. Brit.*); Zanzibar (*v. der Decken*); Réunion (*Maillard*); Nicobars (*Heller*); Sooloo Island (*Dana*); Moluccas, Flores (*v. Martens*); Philippines (*Coll. Brit. Mus.*); Ousima (*Stimpson*); New Hebrides, Mallicollo (*Coll. Brit. Mus.*); Fiji Islands, Ovalau (*Dana*; *Coll. Brit. Mus.*); Samoa or Navigators' Islands (*Coll. Brit. Mus.*); Sandwich Islands (*Dana*); Tahiti (*Heller, Coll. Brit. Mus.*); California, Cape St. Lucas (*Stimpson, Coll. Brit. Mus.*).

This species, as has already been observed, is the most common and widely distributed of the family, and varies somewhat in the form of the frontal lobes, tarsal joints, &c. In the figure given by Milne-Edwards, in the 3rd edition of Cuvier's 'Règne Animal,' and Guérin in the 'Iconographie,' and in specimens observed by Hilgendorf from Zanzibar, as in one specimen in the British-Museum collection, from Australia, there is a small tooth in the notch separating the median frontal teeth; but this peculiarity can hardly be considered to indicate a distinct variety of the species. The greater number of the specimens in the Museum are of the female sex; and between these and the males I have not remarked any striking sexual distinctions; the terminal segment of the male, however, is narrower than that of the female. The length of the carapace of the largest specimens in the collection does not exceed $1\frac{1}{3}$ in.

I have not discovered among the Banksian specimens now in the British Museum the type specimen of Fabricius's *H. adactyla*, which has been referred to by Milne-Edwards as synonymous with this species, but is described as having "*cauda inflexa, articulo primo longitudine thoracis*," which certainly does not apply to it; and I therefore retain the designation *testudinarius*, by which it is generally known.

I follow Hilgendorf in uniting *R. pictus*, Heller, and *R. ovalis*, Edw., with this species, as no characters are given which suffice to distinguish them from the common form. The same may be said of *R. pacificus* and *hirtipes*, Dana: of the former species specimens from the Smithsonian Institution are in the British-Museum collection which certainly belong to *R. testudinarius*.

Var. DENTICULATIFRONS. Pl. V. fig. 2.

Remipes denticulatifrons, *White, List Crust. Brit. Mus.* p. 57 (1847), sine descr.

In this variety the lateral lobes of the front are narrower, spini- or tuberculiform, and project beyond the level of the median lobes. The frontal margin in the adult is denticulated. The striations of the lateral margins are smaller than in the typical variety, forming a very narrow marginal band. The terminal joint of the second and third pair of legs is much more strongly falcate, its distal half narrower, and its apex more acute.

Hab. Zanzibar; Philippine Islands, Maibate; Java; New Hebrides, Aneiteum; Loyalty Islands, Lifu; Galapagos, Charles Island (*Coll. Brit. Mus.*).

The characters of this variety are so marked in the adult that I was at first inclined to consider it a distinct species; but they are much less evident in the young animal. Most of the specimens I have examined are of the female sex; but the characters are not sexual, as there are adult females of the preceding variety in the collection. It would appear, from the localities given above, that the range of this form is equal in extent to that of the typical variety. The largest specimen, that to which White originally applied the name, is much larger than any other of the genus which I have seen—the carapace having a length of $1\frac{2}{3}$ inch, and greatest breadth of $1\frac{1}{2}$ inch.

REMIPES SCUTELLATUS.

Squilla barbadensis ovalis, *Petiver, Pterigraph. Amer.* pl. xx. fig. 9.
Hippa scutellata, *Fabr. Ent. Syst.* ii. p. 474 (1793).
Remipes scutellatus, *List Crust. Brit. Mus.* p. 57, sine descr. (1847).
Remipes cubensis, *Saussure, Rev. et Mag. Zool.* ix. pp. 304, 308 (1857); *Mém. Soc. Phys. et Hist. Nat. Genève*, xiv. p. 452, pl. ii. fig. 19 (1858).
Remipes barbadensis, *Stimpson, Ann. Lyc. Nat. Hist. New York*, x. p. 120 (1871).

Body depressed, broad. Front very broad, anterior margin sinuated on either side of the very slightly prominent median frontal lobe, which is less acute than in *R. strigillatus.* The obliquely striated area forms a narrow marginal band on each side of the carapace, and is but very little broader posteriorly. Eye-peduncles short, projecting but very little beyond the penultimate joint of the antennules—which is scarcely visible from above, beyond the frontal margin of the carapace. Anterior legs of moderate length; terminal joint slightly compressed, with two strong oblique setose ridges on its extero-inferior surface. Ter-

minal joints of the second and third pairs of legs falcate, with the distal as long as, and slenderer than the proximal half. Inner ramus of the appendages of the penultimate segment longer than the outer. Terminal segment elongated-lanceolate. Length of carapace of largest specimen nearly 1 inch.

Hab. Cuba (*Saussure, Coll. Brit. Mus.*); Barbadoes (*Prof. Gill, Coll. Brit. Mus.*); Key Biscayne, Florida (*G. Wurdemann*); St. Christopher's (*Coll. Brit. Mus.*); St. Vincent, Cape-Verdes (*Cunningham, Coll. Brit. Mus.*); Ascension Island (*Coll. Brit. Mus.*); West Africa (*Coll. Brit. Mus.*).

There can be little doubt that the *R. cubensis* of Saussure and *R. barbadensis* of Stimpson are identical. Stimpson does not indicate any distinct specific characters in his description of the latter species; and there are even specimens from Barbadoes in the British-Museum collection, received from the Smithsonian Institution, labelled *R. cubensis.* The specimens named by Dr. Leach *R. scutellatus*, and mentioned by White in the 'List of Crustacea' (*l. c.*), which in all probability were the type specimens of the *Hippa scutellata* of Fabricius, are the types of my description of this species. It is to be observed, however, that Fabricius in his short description says, "*manibus chelatis*; *chelæ læves.*" It is possible that Fabricius mistook the maxillipedes, which present a subchelate appearance when applied to the buccal cavity, for the anterior legs. His description as it stands would certainly apply better to a species of *Lepidops*, to which it is considered to belong both by the earlier authors and Dr. Stimpson.

REMIPES STRIGILLATUS. Pl. V. figs. 3, 4.

Remipes strigillatus, *Stimpson, Ann. Lyc. Nat. Hist. New York*, vii. p. 241 (1862).

Body much depressed, broad. Front very broad, with a very slightly projecting median frontal lobe, anterior margin nearly straight, entire, smooth. The obliquely striated area on the sides of the carapace very broad in its posterior half, where it occupies one fourth of the width of the carapace, striæ sharp, minutely setose, not interrupted, but extending quite to the margin. Eye-peduncles short, reaching to the end of the penultimate joint of the antennules. First pair of legs short, terminal joint slightly compressed, with two strong oblique setose ridges on its extero-inferior surface. Terminal joints of the second and third pairs of legs short, broad, obtuse, and very slightly falcate. Inner

ramus of the appendages of the penultimate segment but little longer than the outer. Last segment oblong-lanceolate.

Hab. Cape St. Lucas (*Stimpson, Coll. Brit. Mus.*).

The broad striated area on the sides of the carapace at once serves to distinguish this species. The three specimens of this species in the British-Museum collection from the Smithsonian Institution are of small size, length of the carapace of the largest not exceeding $\frac{7}{12}$ inch (Stimpson gives 1 inch as the length of the carapace). The median frontal projection is very obscure; and in one specimen the anterior margin appears nearly straight.

REMIPES TRUNCATIFRONS, sp. n. Pl. V. figs. 5, 6.

Body depressed; frontal margin straight, entire, smooth, with scarcely any trace of a median frontal lobe. Sides of the carapace without any trace of the defined striated marginal area existing in other species of the genus. Eye-peduncles very slender, projecting but little beyond the rather prominent penultimate joint of the antennules; cornea small, subterminal. Anterior legs small and slender; terminal joint of the second and third pairs of legs short, broad at base, distinctly falcate, with the distal portion much slenderer than the proximal. Outer ramus of the appendages of the penultimate segment of the postabdomen much shorter than the inner. Terminal segment oblong-lanceolate.

Hab. China (*J. R. Reeves, Esq., Coll. Brit. Mus.*).

The obsolescence of the median frontal lobe, and the absence of a lateral marginal striated area, serves to characterize this species. The eye-specks, viewed from above, are placed at a little distance from the distal extremity of the peduncle. The single specimen in the British-Museum collection is a female. Length of carapace $\frac{7}{12}$ inch.

MASTIGOCHIRUS.

Mastigopus*, *Stimpson, Proc. Ac. Nat. Sci. Phil.* p. 230 (1858) (nom. præoc.).

Antennules and antennæ short. Third maxillipedes rather slender. First legs very long and very slender, with the last joint especially greatly elongated and multiarticulate.

* This name was adopted in 1853 by Leuckart (Wiegm. Archiv f. Naturg. xix. p. 258) for a curious Macrurous Crustacean. I have, therefore, altered the termination, whilst retaining the allusion to the whip-like character of the anterior legs.

The two species known of this remarkable genus are both from the Asiatic Region, perhaps the richest in remarkable forms of all the great geographical areas.

MASTIGOCHIRUS GRACILIS. Pl. V. fig. 7.

Mastigopus gracilis, *Stimpson, Proc. Ac. Nat. Sci. Phil.* p. 244 (1858).

Carapace elongate-ovate, very convex, with short crenulated setose lines. Front 3-toothed; the median tooth triangular, the lateral slender, and longer than the median one. Antero-lateral margins 6-toothed, the teeth diminishing in length posteriorly. Eyes slender, and more than half as long as the antennules. Second joint of the maxillipedes oblong, longer than broad. Anterior legs greatly elongated, slender, cylindrical; the dactylus is longer than the carapace, and consists of 12–14 elongated joints; terminal joints of the legs of the second and third pairs very slightly falcate. Last segment of the postabdomen elongate, thick, longitudinally sulcate in the middle, and bicarinate near its base. Length about ½ inch.

Hab. China Seas (*Stimpson, Coll. Brit. Mus.*).

The single example of this species in the national collection was presented by the Smithsonian Institution.

MASTIGOCHIRUS QUADRILOBATUS, sp. n. Pl. V. fig. 8.

Body elongate-ovate, very convex, marked with short crenulated setose lines, as in the preceding species. Front 4-lobed, the two median lobes small, rounded, and not nearly as prominent as the spiniform lateral lobes. The striated lateral area is reduced to a narrow line, bordering the whole length of the carapace, which is without lateral marginal teeth. Eyes long, slender, and half as long as the antennules; second joint of the maxillipedes broad, with the inner margin arcuate. Anterior legs very long, when thrown forward longer than the body; the terminal joint consists of ten or a dozen obscure unequal joints, and is clothed with long fulvous hairs; the terminal joints of the second and third pairs of legs are long, and very slightly falcate. The outer ramus of the appendages of the penultimate segment is about half as long as the inner. The terminal segment is oblong-lanceolate. Length of carapace 5 lines.

Hab. Philippine Islands, Guimaras (*Coll. Brit. Mus.*).

The form of the front, and the absence of antero-lateral marginal teeth, at once distinguish this species from the foregoing.

The single specimen in the Museum was purchased of H. Cuming, Esq.

Hippa.

Hippa, *Fabr.* (*part.*), *Mantissa Ins.* i. p. 329 (1787); *M.-Edw. Hist. Nat. Crust.* ii. p. 207 (1837); *Stimpson, Proc. Ac. Nat. Sci. Phil.* p. 230 (1858).

Antennules of moderate length. Antennæ with a very long, robust, multiarticulate, and strongly ciliated flagellum. Third maxillipedes with the last joint narrow, laminate, and compressed. First legs with the last joint lamellate-oval.

The species of this genus, of which two inhabit the opposite shores of the American continent, and one the Indian and Indo-Malayan region, bear a very close resemblance to one another; but the distinctive characters, although slight, appear constant in large series of specimens.

Hippa emerita. Pl. V. fig. 9.

? Cancer emeritus, *Linn. Syst. Nat.* (ed. 12) p. 1055 (1766).

? Astacus emeritus, *Fabr. Ent. Syst.* ii. p. 484 (1793).

Cancer testudinarius, *Herbst, Naturg. Krabben*, ii. p. 8, pl. xxii. fig. 3 (1796).

Hippa emeritus, *Fabr. Ent. Syst. Suppl.* p. 370 (1798).

Hippa emerita, *Latr.* (?) *Hist. Nat. Crust.* vi. p. 176 (1803); *Lamarck* (?), *Hist. Anim. sans Vert.* v. p. 222 (1818); *Desmarest, Consid. Crust.* p. 174, pl. xxix. fig. 2 (1825); *M.-Edw. Hist. Nat. Crust.* ii. p. 209 (1837); *Crust. in Cuvier R. A.* (ed. 3) pl. xlii. fig. 2; *Gibbes, Proc. Amer. Assoc.* p. 188 (1850); *Dana, U.S. Expl. Exp.* xiii. *Crust.* i. p. 409, pl. xxv. fig. 9 (1852); *Guérin-Méneville, Icon. R. A. Crust.* pl. xv. fig. 2; *in Ramon de la Sagra, Hist. Isla de Cuba*, vii. *Crust.* p. xxxiv. (1856); *Heller, Crust. in Reise der Novara*, p. 73 (1865).

Hippa talpoidea, *Say, Journ. Ac. Nat. Sci. Phil.* i. p. 160 (1817); *De Kay, Zool. New York Fauna*, pt. vi. p. 18, pl. vii. fig. 17 (1844); *Gibbes, Proc. Amer. Assoc.* p. 188 (1850); *Smith, Trans. Conn. Ac.* iii. p. 311 (1877).

Body very convex. Median lobe of the front *triangular, subacute*, and separated from the lateral lobes by a distance usually greater than its own breadth at base; the lateral frontal lobes are narrow, acute, and much more prominent than the median lobe. Carapace marked with irregular crenulated transverse lines, which are nearly obliterated on the sides and towards the posterior margin; and with a distinctly marked postfrontal and postgastric incised line. Eyes very long and slender. Antennules densely

hairy. Second joint of outer antennæ with three spines at its distal extremity, of which the median is very much the longest, *and directed slightly outward*; flagellum very long, robust, multi-annulated, and ciliated on its outer margin. Third joint of the outer maxillipedes with the lobe at its antero-internal angle triangular and subacute. Terminal joint of the first pair of legs ovate; those of the second and third pairs of legs falcate, very broad at base, narrow and subacute in their terminal halves. Rami of the appendages of the penultimate postabdominal segment short, the outer shorter and broader oval than the inner.

The length of the carapace of the largest specimen from Brazil is 1 inch 2 lines; but in a specimen of uncertain locality in the collection the carapace is nearly $1\frac{3}{4}$ inch long.

Hab. Brazil (*Mus. Paris, Brit.*); Rio Janeiro (*Dana, Heller, Coll. Brit. Mus.*); Five-Fathoms Bay (*Coll. Brit. Mus.*); Venezuela (*Coll. Brit. Mus.*); Martinique (*Herbst*); Cuba, Mexico (*Guérin-Méneville*); United States (*Coll. Brit. Mus.*); Boston, New York, Charleston Harbour, Key West (*Gibbes*).

Specimens from Mazatlan, referred to this species by De Saussure, belong in all probability to *H. analoga*. I think there can be little doubt that *H. talpoidea*, Say, is identical with the Brazilian *H. emerita*, although Gibbes, founding his conclusions upon a comparison of four specimens from Carolina with two from Brazil, is of the opposite opinion. The specimens from the United States in the British Museum, presented by Say, are small, and scarcely suffice to determine the question, but certainly do not appear specifically distinct.

According to De Kay (*l. c.*) and Smith (Trans. Conn. Ac. iii. p. 111, 1877), *H. talpoidea* inhabits the entire eastern coast of the United States from Cape Cod southward to the west coast of Florida, Egmont Key being the most southern and western habitat known to the latter author.

It is impossible to say to what species belong the specimens from the Sandwich Islands referred by Randall to *H. emerita*, as no description accompanies them.

HIPPA ANALOGA. Pl. V. fig. 10.

Hippa emerita, *M.-Edw. & Lucas, Crust. in D'Orbigny's Voy. Amér. mérid.* vi. p. 32 (1843); *Nicolet, Crust. in Gay, Hist. Chile,* iii. p. 185 (1849); *De Saussure, Rev. et Mag. Zool.* v. p. 367 (1853), nec *Edwards.*

Hippa talpoides, *Dana, Crust. in U.S. Expl. Exp.* xiii. 1, p. 409, pl. xxv. fig. 10 (1852); *Proc. Ac. Nat. Sci. Phil.* vii. p. 175 (1854), nec *Say*.
Hippa analoga, *Stimpson, Proc. Boston, Soc. Nat. Hist.* vi. p. 85 (1856–59); *Journ. Bost. Soc. Nat. Hist.* vi. p. 486 (1857).

This species is nearly allied to *H. emerita*; but the carapace is generally more rugose anteriorly, and the posterior margin is straight. *The median frontal lobe is broader, less acute, and not separated so widely from the lateral lobes*, which are acute but far less prominent. The median spine of the second joint of the antennæ is proportionally not so long, *and is directed slightly inward* (not outward, as in *H. emerita*). The lobe of the antero-internal angle of the third joint of the outer maxillipedes, in the specimens I have examined, is broader, more rounded, and less prominent. Length of the carapace of the largest specimen about 1 inch 2 lines.

Hab. Chili, Valparaiso (*M.-Edw. & Lucas, Dana*); Chiloe, Ancud, Luco Bay, and San Vincente (*Cunningham, Coll. Brit. Mus.*); Mexico (*Coll. Brit. Mus.*); Mazatlan (*Saussure*); California, Tomales Bay (*Stimpson*); San Francisco and Monterey (*Stimpson, Coll. Brit. Mus.*).

There are in the British-Museum collection two specimens obtained by purchase, and labelled as having been obtained, with a number of other Crustacea, from "New Zealand and New Holland." They are of small size; carapace about 7 lines in length, and appear to belong to *Hippa analoga*, the form of the frontal lobes and second joint of the antennæ being the same. There may be some mistake in regard to their habitat.

HIPPA ASIATICA. Pl. V. fig. 11.

Hippa asiatica, *Milne-Edwards, Hist. Nat. Crust.* ii. p. 209 (1837); *Heller, Reise der Novara, Crust.* p. 73 (1865).

The specimens which I refer to this species are very nearly allied to the two preceding, but differ from them in the following particulars:—The body is very convex and narrow, appearing almost cylindrical when viewed from above. The lobes of the front are very narrow and acute, the median is separated by an interval of nearly twice its own breadth from the lateral ones, which do not project much beyond it. The median spine of the second joint of the antennæ is very long, and bent very slightly inward. The antero-internal lobe of the third joint of the maxillipedes is broad, rounded, and but little prominent. The terminal joint of the

first pair of legs is acute, and terminates almost in a spine. Length of carapace of largest specimen, 1 inch 2 lines.

Hab. Seas of Asia (*Mus. Paris*); Ceylon (*Heller, Mus. Brit.*); Madras (*Heller*); India, Java (*Mus. Brit.*).

Fam. ALBUNEIDÆ.

Albunidæ, *Stimpson, Proc. Ac. Nat. Sci. Phil.* p. 230 (1858).

Anterior legs terminating in a more or less perfectly subchelate hand. Third maxillipedes subpediform (the third joint not greatly enlarged), and furnished with an exognath. Last tail-segment not greatly elongated, ovate-lamellate.

ALBUNEA.

Albunea, *Fabr. Ent. Syst. Suppl.* pp. 372, 397 (1798); *M.-Edw. Hist. Nat. Crust.* ii. p. 202 (1837).

Albunæa, *Stimpson, Proc. Ac. Nat. Sci. Phil.* p. 230 (1858).

Eye-peduncles lamellate compressed; cornea very small. Antennules with an extremely long multiarticulate flagellum. Second joint of antennæ with a narrow but well-developed accessory joint; flagellum very short. Third maxillipedes with the third joint but slightly enlarged, and the fourth joint but shortly produced at its antero-external angle.

ALBUNEA SYMNISTA.

Cancer symnista, *Linn. Syst. Nat.* p. 1053 (1766).

Hippa symnista, *Fabr. Ent. Syst.* ii. p. 474 (1793).

Cancer dorsipes, *Herbst, Naturg. Krabben u. Krebse,* ii. p. 5, pl. xxii. fig. 2 (1796), nec *Linn.*

Albunea symnista, *Fabr. Ent. Syst. Suppl.* p. 397 (1798); *Latr. Hist. Crust.* vi. p. 172 (1803); *Lamarck, Hist. Anim. sans Vert.* v. p. 224 (1818); *Desmarest, Consid. Crust.* p. 173, pl. xxix. fig. 3 (1825); *M.-Edwards, in Cuvier's Règne Animal* (ed. 3), *Crust.* pl. xlii. fig. 3; *Hist. Nat. Crust.* ii. p. 203 (1837); *Guérin-Méneville, Icon. Règne Anim. Crust.* pl. xv. fig. 1; *Heller, Crust. in Voy. Novara,* p. 72 (1865).

Moderately convex, shining; carapace marked with transverse interrupted impressed lines, of which the postfrontal and the angulated line separating the gastric from the branchial region are the most distinct. Anterior margin with 12–14 closely placed spiniform teeth, a semicircular median emargination, and a small median tooth. Antero-lateral angles of the carapace with a small acute spine. Eye-peduncles *about twice as long as broad at base, with their outer margins arcuated*; the cornea minute. Antennæ not longer than the carapace, very hairy; basal joint with

a spine at its antero-external angle; flagellum with the joints diminishing successively in size. Antennules very long, exceeding the body in length; the flagellum multiarticulate, and fringed with long hairs on its upper and inner margin. Anterior legs with the hand very short, and high in proportion to its length, with short interrupted and setose ridges on its outer surface; its anterior margin straight, with a short spine at the antero-inferior angle; finger arcuate, acute. Terminal joint of second pair of legs strongly falcate, the distal half rather sharply bent; that of the *third pair slender, arcuate, with a prominent and narrow lobe near its proximal end*; that of the fourth pair broad, slightly falcate, and acute at its distal extremity. Terminal joint of the postabdomen longer than broad, spatulate, ovate, not narrowed and produced at its distal extremity. Length of carapace about 1 inch.

Hab. India, Pondicherry (*Coll. Brit. Mus.*); seas of Asia (*Coll. Mus. Paris*); East Indies, Amboina (*Herbst*); Nicobars, Madras (*Heller*).

Albunea symnista, Fabr., is mentioned by Brullé in his list of the Crustacea inhabiting the Canaries, given in Webb and Berthelot's Hist. Nat. des îles Canaries, ii. Zool. Crust. p. 17; but this may prove on comparison to be one of the species inhabiting the Mediterranean or Eastern American coast.

In the males of this species the terminal segment is notched at its base, where it is articulated with the penultimate, and attains its greatest width near its broadly rounded distal extremity, toward which it is suddenly narrowed. In the females this segment is narrow-ovate (see Lucas, Rev. et Mag. Zool. v. p. 47, pl. i. fig. 8, *a*, *b*).

The form of the eye-peduncles, with the number of teeth on the anterior margin of the carapace, and the form of the terminal joint of the third pair of legs, suffice to distinguish *A. symnista* from its congeners.

ALBUNEA GUERINII *.

Albunea symnista, *Lucas, Crust. in Explor. Algérie*, p. 27, pl. iii. fig. 2 (1849); *Heller, Crust. südl. Europa*, p. 153 (1863).

* It is possible that this is the species described by Linnæus (Syst. Nat. p. 1052) from the Mediterranean, under the name of *Cancer carabus*. By "*Rostrum dentibus 2 parallelis mobilibus depressis*," the eye-peduncles may be meant. The remainder of the description would apply fairly well to a species of the genus *Albunea*.

Albunea guerinii, *Lucas, Rev. et Mag. Zool.* (sér. 2) v. p. 47, pl. i. fig. 9 (1853).

This species, according to M. Lucas, differs from *Albunea symnista* (with which species he confounded it in the Explor. Algérie, i. p. 27, pl. iii. fig. 2) in the shorter and narrower ocular peduncles, less elongated and crowded frontal spines, which are broader at base, and in the form of the terminal segment of the postabdomen, which is altogether cordiform in the male, broader and ovate in the female. Length of the male 30–33 millims. (1 inch 2–3½ lines); of female 40 millims (nearly 1 inch 7 lines).

Hab. Gulf of Algiers (*Lucas*).

As compared with *A. symnista*, M. Lucas has shown (*l. c.* fig. 9, *a*, *b*) that the terminal segment is scarcely notched, and attains its greatest width nearer the base than the distal extremity, which is represented as more acute than in that species. In the female the terminal segment in *A. guerinii* is more broadly ovate.

No explanation of the figures accompanies the description of this species; but if, as appears certain, the figure 9 *b* represents the tarsus of the third pair of legs, a comparison of it with the same joint of *A. symnista* figured on the same plate (fig. 8 *d*) reveals another very marked distinction between the two species. In *A. symnista*, as stated above, the terminal joint has a prominent narrow linear lobe near its articulation with the preceding joint. In *A. guerinii* this lobe is *almost obsolete*, scarcely indicated by an obscure tubercle.

ALBUNEA MICROPS, sp. n. Pl. V. figs. 12, 13.

Albunea microps, *White, List Crust. Brit. Mus., Append.* p. 129 (1847), descript. nulla.

In this species the carapace is somewhat broad and depressed, with nine teeth on its anterior margin; the eye-peduncles are even broader and shorter than in *A. symnista*, being not twice as long as broad at the base; and the cornea is borne on a small tuberculiform lobe or prominence. The terminal joint of the third pair of legs is slightly broader, but not lobate at its proximal end. The last segment of the postabdomen of the male is nowhere as broad as that of *A. symnista*, and is narrowed to its rounded distal extremity. Length of carapace a little over ½ inch.

Hab. Sooloo Island (*Coll. Brit. Mus.*).

A single specimen is in the collection.

The rami of the appendages of the sixth segment are arcuate,

the inner longer and much narrower than the outer. The terminal segment is membranaceous in its distal half, and the lateral margins are inflexed. The transverse interrupted ridges on the carapace are very distinctly marked, giving the animal a rugose appearance.

ALBUNEA GIBBESII.

Albunea symnista, *Gibbes, Proc. Amer. Assoc.* p. 187 (1850).
Albunea gibbesii, *Stimpson, Ann. Lyc. Nat. Hist. New York*, vii. p. 78, pl. i. fig. 6 (1862).

This species bears a general resemblance to *A. symnista*; but the carapace is much broader in proportion to its length. There are but six or eight teeth on the anterior margin of the carapace. The ocular peduncles are narrower in proportion to their length, and their outer margin is straight. The last joint of the second pair of legs has a broadly triangular, not a narrow and prominent lobe near its proximal end; that of the third pair is broader than in *A. symnista.* The inner ramus of the penultimate pair of post-abdominal appendages is much broader and nearly as long as the inner; and its terminal joint in the male is somewhat oblong, *with a narrow prolongation at its distal extremity.*

Hab. Florida, St. Augustine and among the Keys (*Stimpson*); Charleston Harbour (*Gibbes*); south-eastern coast, United States (*Coll. Brit. Mus.*).

The single specimen of this species in the British-Museum collection is a male. The form of the terminal segment in the female is not stated; that of the same segment in the male serves to distinguish the species from all its congeners. The length of the carapace a little exceeds 1 inch.

ALBUNEA OXYOPHTHALMA. Pl. V. figs. 14, 15.

Albunea oxyophthalmus, *Leach* (*MS.*); *White, List Crust. Brit. Mus.* p. 57 (1847), sine descr.

This species is nearly allied to *A. symnista*, but differs as follows:—The eye-peduncles are very long, narrow, more than three times as long as broad at the base, with their outer margins straight. There are ten to twelve teeth on the anterior margin of the carapace, on each side of the median notch. The lobe at the proximal end of the last joint of the third pair of legs is prominent, triangular, and acute, but not so narrow at base as in *A. symnista.* The terminal segment of the postabdomen in the male is scarcely longer than broad, broadest in the middle, nearly

straight at its proximal extremity; that of the female is longer than broad, oblong-ovate. Length of carapace of largest specimen about $1\frac{1}{3}$ in.

Hab. West Indies, St. Christopher's; Cayenne; Brazil (*Coll. Brit. Mus.*).

In this species, as in all the preceding, the spine at the antero-lateral angle of the carapace is of moderate length, not reaching beyond the level of the anterior margin of the carapace, and the median semicircular emargination of the front about twice as wide as deep.

Albunea paretii, Guérin-Méneville, Rev. et Mag. Zool. sér. 2, v. p. 48, pl. i. fig. 10 (1853), may not improbably belong to this species. The type specimen was, as its author states, given to him by the Marquis Pareto with some Crustacea obtained in the neighbourhood of Genoa; but he had also received other Crustacea from America from the captain of a merchant vessel, and consequently was unable to speak positively as to the habitat of the species. It differs from *A. symnista* and *A. guerinii* principally in its elongated and very narrow eye-peduncles (which are represented as even longer and narrower at base than are those of *A. oxyophthalma*), subelongate and less crowded frontal spines, and narrower terminal postabdominal segment. The uncertainty of the habitat and brevity of the description render it impossible to determine its position with certainty, without an examination of the typical specimen.

ALBUNEA LUCASII.

Albunea lucasia, *Saussure, Rev. et Mag. Zool.* v. p. 367, pl. xii. fig. 4 (1853).

Albunea lucasii, *Stimpson, Journ. Bost. Soc. Nat. Hist.* vi. p. 485 (1857).

This species is characterized by De Saussure as having a very deep median frontal emargination, styliform ocular peduncles, and a very long spine on each side of the carapace. Length of carapace about 1 inch.

Hab. Mazatlan (*De Saussure*).

This species, in the form of the eye-peduncles, very nearly resembles the preceding; but the differences instanced by De Saussure appear sufficient to warrant its specific separation, if regard be had to its recorded habitat being on the western, not the eastern, coast of the American continent. In De Saussure's figure of the carapace, the frontal margin is represented as 8–10-

toothed, the median frontal notch not wider than deep, and the spine at the antero-lateral angle much longer than in *A. oxyophthalma*. The anterior legs were wanting; and nothing is said of the form of the tarsal joints of the remaining legs, or of the form of the terminal segment, by De Saussure.

ALBUNEA SPECIOSA.

Albunea speciosa, *Dana, U.S. Expl. Exp.* xiii. *Crust.* i. p. 405, pl. xxv. fig. 6 (1852).

This species is characterized by Dana as having the carapace marked with transverse lines, anterior margin either side of middle about 10-toothed, sides of thorax nearly parallel; peduncles of eyes slender, attenuate; anterior or upper margin of last joint of fourth pair of legs nearly straight; terminal segment a little oblong, quite entire, at apex subtriangular, its sides nearly parallel, sparingly arcuate. Length of carapace 7½ lines.

Hab. Sandwich Islands (*Dana*).

This species appears to be well characterized by the form of the eye-peduncles, which are represented in the figure as much narrower in their distal than in their proximal half; *concave, not convex or straight, on their outer margins.* The spine at the antero-lateral angle is very small, and does not reach to the anterior margin of the carapace. The form of the tarsal joint of the third pair of legs is not mentioned; that of the fourth pair is broad and scarcely at all falcate. The terminal segment (apparently of the female) is oblong-ovate. I have seen no specimens of this species.

LEPIDOPS *.

Lepidopa, *Stimpson, Proc. Ac. Nat. Sci. Phil.* p. 230 (1858).

Eye-peduncles lamellate, compressed, almost squamiform, cornea not visible. Antennules long. Antennæ with a very small accessory joint, flagellum very short. Third maxillipedes with the fourth joint produced at its antero-external angle into a lobe, which reaches to or beyond the distal extremity of the fifth (penultimate) joint.

By the opposition of the last two joints of the third maxillipedes to the lobe of the antepenultimate joint, a prehensile organ is developed similar to that formed in the same pair of limbs in

* The generic name *Lepidopa* is more correctly written *Lepidops* by Stimpson in his description of *L. myops*.

certain Amphipoda (e.g. *Cerapus*), except that in the Amphipoda the antepenultimate joint is produced at its antero-inferior angle.

The species are all from America.

Lepidops scutellata.

Albunea scutellata, *Desm. Consid. Crust.* p. 173 (1825); *M.-Edw. Hist. Nat. Crust.* ii. p. 204, pl. xxi. figs. 9–13 (1837); *Gibbes, Proc. Amer. Assoc.* p. 187 (1850); *Dana, U.S. Expl. Exp.* xiii. *Crust.* i. p. 406 (1852).

Lepidopa scutellata, *Stimpson, Proc. Ac. Nat. Sci. Phil.* p. 230 (1858); *Ann. Lyc. Nat. Hist. New York*, vii. p. 79 (1862).

Carapace scarcely emarginate, and without any noteworthy denticles or spines on its anterior margin. Eye-peduncles much broader than long, and truncate anteriorly. Length of carapace 7 lines.

Hab. Peru, San Lorenzo? (*Dana*); Island of St. Thomas (*A. H. Riise*).

No locality is mentioned by Desmarest * or Milne-Edwards for this species. Dana observes of the specimens collected at San Lorenzo that the proportions are different from those in the figure by Edwards. The hand is very thin and high, the height being equal to the length; the lower margin is slightly arcuate, and not at all deflexed at the base of the immobile finger; this finger is acute and short, the margin above it vertical and hairy. The front margin has a low median point, and also another equally advanced, halfway to the side, with the margin between sinuous. It is not improbable that the specimens from St. Thomas and San Lorenzo may prove upon comparison to belong to distinct species. Length of carapace of female 6 lines. I have seen no specimens.

Lepidops venusta.

Lepidopa venusta, *Stimpson, Proc. Ac. Nat. Sci. Phil.* p. 230 (1858, sine descr.); *Ann. Lyc. Nat. Hist. New York*, vii. p. 79 (1862).

Carapace glabrous, of a silvery hue, with bluish reflections (in specimens preserved in spirits). The markings of the dorsal surface of the carapace are less profound and less numerous than in *L. scutellata*; and the principal transverse sulcus is nearly straight and not undulated as in that species. Front tridentate; lateral teeth situated at about halfway between the median one and the lateral angles, and consequently nearer the median one

* Desmarest considered his specimens to be the *Hippa* (*Albunea*) *scutellata* of Fabricius; but see above, under *Remipes scutellatus*.

than in *L. scutellata.* Eye-peduncles large, oval, diverging, and a little thickened below the middle, the minute eye being situated on the inferior surface near the extremity. Antennules slender, with flagella more than five times as long as the carapace. Feet nearly as in *L. scutellata*; but the dactylus of the second pair is more sharply excised, and the dactyli of the following pairs are more slender.

Hab. St. Thomas (*Stimpson*). I have seen no specimens of this species.

Lepidops myops. Pl. V. fig. 16.

Lepidops myops, *Stimpson, Ann. Lyc. Nat. Hist. New York,* vii. p. 241 (1862).

Carapace with the same markings on the surface as in *L. scutellata,* but stronger. Postfrontal transverse groove broad, with granulated surface. Median lobe of front rounded; margin armed with small teeth like those of a comb, which become more conspicuous outwardly as far as the lateral lobes, where the margin becomes smooth. Eye-peduncles or scales obliquely oblong, rather thick, broader behind, antero-lateral angle prominent, subacute; inner angle rounded; eye-specks obsolete in most of the specimens, in others barely visible on the inferior side of the ocular plate, near the exterior angle. In other characters this species approaches very near to *L. scutellata.*

Hab. Cape St. Lucas (*Stimpson, Coll. Brit. Mus.*).

Two specimens (a male and a female) are in the British-Museum collection, from the Smithsonian Institution. The fifth segment in both sexes has slender lateral lobes or wings. The terminal segment in the male is triangular, broad, and rounded on the sides at its proximal and acute at its distal extremity; that of the female is ovate-triangular, more rounded and obtuse at its distal extremity. They are both of small size. Length of carapace about 5 lines.

Blepharopoda.

Blepharipoda, *Randall, Journ. Ac. Nat. Sci. Phil.* viii. p. 130 (1839); *Stimpson, Proc. Ac. Nat. Sci. Phil.* p. 230 (1858).

Albunhippa, *M.-Edw. & Lucas, Arch. Mus. Hist. Nat.* ii. p. 477 (1841).

Abrote, *Philippi, Arch. f. Naturg.* xxiii. p. 124 (1857).

Eye-peduncles very slender, elongated, cylindrical, and articulated in the middle. Antennules and antennæ rather long, and with a multiarticulate flagellum; antennæ without an accessory joint.

Third maxillipedes with the third joint narrow and similar to the fourth, which is not produced at its antero-external angle.

It is possible that the three species of this genus belong in reality to one and the same form; but as I have not the material on which to base an accurate comparison, it may be advisable to consider them for the present as distinct. All are from the western American coast.

BLEPHAROPODA OCCIDENTALIS.

Blepharipoda occidentalis, *Randall, Journ. Ac. Nat. Sci. Phil.* viii. p. 131, pl. vi. (1839); *Gibbes, Proc. Amer. Assoc.* p. 187 (1850); *Stimpson, Journ. Bost. Soc. Nat. Hist.* vi. p. 486 (1857).

Carapace convex, somewhat obliquely elevated toward the centre, which is faintly carinate; a median transverse sinuous impression, behind which the surface is polished, but anterior to it densely marked with small transverse impressions, most of which are pectinate and hairy; a lateral transverse impression and a very profound oblique one connected with it inferiorly; frontal edge strongly 3-toothed, and excavated between the teeth; a distinct postfrontal transverse groove, behind which is a strong tooth; antero-lateral margin of the carapace with four stout teeth on each side, posterior margin excavated: second, third, and fourth pairs of feet more or less roughened laterally, and with the anterior edge minutely dentate; anterior pair stout; arm with a strong tooth near its anterior inferior extremity; carpus elongate, rather convex, laterally impressed, and having on its upper anterior edge a great spiniform crest, which is itself bordered with smaller spines; hand flattened on the side, and armed with two or three strong sharp teeth, having between them a great multitude of impressions similar to those of the carapace; pincers flattened, acute at tip, and armed with sharp spiniform teeth both on their outer edges and on their prehensile side. Length about 2 inches.

Hab. California, San Diego (*Randall, Stimpson*); Monterey (*Coll. Brit. Mus.*).

The above is Randall's description.

There is in the collection of the British Museum a very much mutilated specimen of this species, gummed in detached fragments on cardboard, from Monterey, California, the imperfect condition of which precludes the possibility of description. It may be noted, however, that the anterior margin of the palm and the outer margin of the mobile finger are armed with a series of four spines, which decrease in size toward the articulation and are

none of them very large. In a second (female) specimen of unknown locality which is in the collection, and appears to belong to this species, the number of spines varies from three to four. The terminal segment is almost orbiculate in outline.

BLEPHAROPODA SPINIMANA.

Abrote spinimana, *Philippi, Archiv f. Naturg.* xxiii. p. 129, pl. viii. (1857).

Blepharipoda spinimana, *Stimpson, Proc. Ac. Nat. Sci. Phil.* p. 230 (1858).

Carapace elongate-ovate and convex above. Front 3-toothed, the teeth triangular, and ending in long spines, the median tooth rather less prominent than the lateral. There is a small median spine immediately behind the groove defining the anterior margin of the gastric region, and four spines on the antero-lateral margins, of which the first is long and the last very small. The eye-peduncles are very slender; and their penultimate about equals the last joint in length. The flagella of the antennæ have a series of long hairs. The anterior legs have the arm short, with a long spine on its inferior margin; wrist with a strong triangular tooth on the upper margin at the distal extremity, behind which is a spine; palm slightly rugose externally, with two spines on its outer surface, one on its inferior margin at its infero-distal angle, and two very strong spines on its anterior margin and on the upper margin of the mobile finger. Terminal joints of the second and third legs strongly falcate, those of the second pair broader and shorter than those of the third pair, those of the fourth pair but slightly falcate, the fifth pair slender, small, and monodactyle. Tail-segments (the last excepted) short, with horizontal ovate lateral lobes; the last joint of the male is twice as broad as the foregoing at base, as broad as long, with the sides converging to the distal extremity.

Hab. Chili, at Tomé, in Bay of Talcahueno (*Philippi*); Bay of Valparaiso (*Coll. Brit. Mus.*).

The specimens described by Philippi were found by Herr Ph. Germain on the sea-shore. The specimen (a male) in the British-Museum collection was found by fishermen in deep water in the Bay of Valparaiso, where it is stated to be of rare occurrence. The length of its carapace is nearly 1 in. 2 lines.

BLEPHAROPODA SPINOSA.

Albunhippa spinosa, *M.-Edw. & Lucas, Arch. Mus. Hist. Nat.* ii. p. 477,

pl. xxviii. figs. 1–13 (1841); *Dana, U.S. Expl. Exp.* xiii. *Crust.* i. p. 406 (1850).

Blepharopoda spinosa, *Stimpson, Proc. Ac. Nat. Sci. Phil.* p. 230 (1858).

Hab. Peru, San Lorenzo (*Dana*).

The locality whence the specimen described by Milne-Edwards and Lucas was obtained is not stated; and there is nothing in their description to distinguish it from either of the foregoing species. The hands are represented in the figure as devoid of spines, but are described as spinose. Dana gives no particulars which would serve to characterize the specimens collected by the U.S. Exploring Expedition.

EXPLANATION OF PLATE V.

Fig. 1. Front of *Remipes testudinarius*, nat. size.
2. ,, ,, ,, var. *denticulatifrons*, also nat. size.
3. *Remipes strigillatus*, Stimpson, nat. size.
4. The same, lateral view.
5. *R. truncatifrons*, n. sp., nat. size.
6. The same, lateral view.
7. *Mastigochirus gracilis*, Stimpson, × 2 diam.
8. *M. quadrilobatus*, n. sp., × 2 diam.
9. Front of *Hippa emerita*, Latr., nat. size.
10. ,, ,, *analoga*, Stimpson, nat. size.
11. ,, ,, *asiatica*, M.-Edw., nat. size.
12. *Albunea microps*, White, MS., nat. size.
13. ,, ,, ,, abdomen of male, × 2 diam.
14. *A. oxyophthalma*, Leach, nat. size.
15. ,, ,, ,, abdomen of male, × 2 diam.
16. *Lepidops myops*, Stimpson, nat. size.

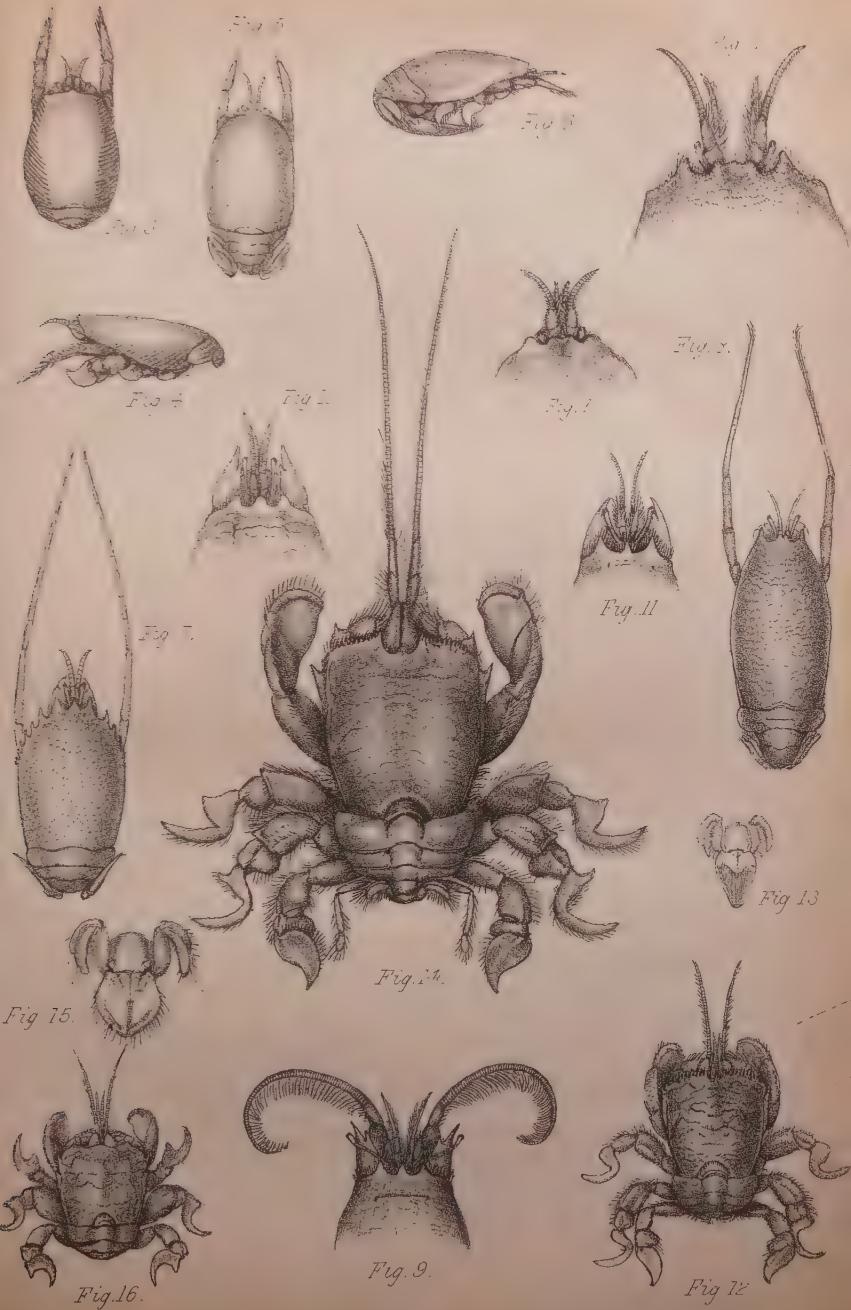
Descriptions of new Species of Phytophagous Coleoptera.

By JOSEPH BALY, Esq., M.R.C.S., F.L.S., &c.

[Read December 20, 1877.]

List of Species and their Habitat.

Sagra longipes	Burmah.
,, *ferox*	South Africa, Ribé.
Megascelis posticata	Pebas, Upper Amazons.
,, *femorata*	Amazons.
,, *basalis*	Rio Janeiro.
Megalostomis placida	Ega, Upper Amazons.
Diaspis batesi	Ega, Upper Amazons.



Berjeau lith. SPECIES OF HIPPIDEA. Hanhart imp.

Chlamys velutina	Amazons.
„ *placida*	Ega, Upper Amazons.
„ *chinensis*	China.
„ *fulvipes*	India.
Lamprosoma tricolor	Amazons, Santarem.
„ *batesi*	Upper Amazons.
„ *hypochryseum* ..	Mexico, Guatemala.
„ *cupricolle*	Ega, Upper Amazons.
„ *amazonum*	Ega, Upper Amazons.
„ *tridentatam* ..	Brazil.
„ *canaliculatum* ..	Upper Amazons, Pebas.
„ *cuneatum*	Cayenne.
„ *armatum*	Columbia.
Doryphora verrucosa	Brazil, Neu-Fribourg.
„ *buckleyi*	Ecuador.
„ *undulata*	Columbia.
„ *dorsomaculata* ..	Bahia.
„ *mœsta*	Columbia, Bogota.
„ *jacobyi*	Ecuador.
Labidomera imperialis	Rio Janeiro.
Deuterocampta saundersi ..	Brazil.

Genus SAGRA, *Fabr.*

SAGRA LONGIPES, n. sp. Elongato-ovata, convexa, viridi-cyanea, nitida, antennis (articulis quinque opacis nigris exceptis) elytrisque metallico-cæruleis; his anguste obovatis ♂, magis oblongis ♀, convexis, infra basin leviter transversim depressis, tenuiter punctato-striatis, striis gemellatis, fere totidem deletis, interspatiis obsolete sinuato-impressis.

Var. A. *Fœm.* corpore dorso (antennis extrorsum exceptis) pedibusque metallico-cæruleis.

Mas femoribus posticis minus incrassatis, corpus valde superantibus, subtus ante apicem spinis duabus, prima valida, armatis; tibiis ejusdem paris elongatis, pone basin paullo recurvatis, deinde ad apicem incurvatis, apice introrsum leviter flexis, apice ipso mucronato, spinis duabus, prima interna valida, intus paullo ante apicem, secunda externa, parva, fere ad apicem positis, armatis.

Fœm. femoribus posticis corpus non superantibus, subtus ad apicem crista brevi instructis; tibiis ejusdem paris regulariter curvatis, simplicibus. Long. ♂ 10 lin., ♀ 9 lin.

Hab. Burmah.

Antennæ three fourths the length of the body in the ♂, rather

shorter in the ♀, six lower joints nitidous, metallic blue, the rest opaque black; second joint rather shorter than the third in the ♂, the latter slightly longer than the fourth; in the ♀ the second joint is much shorter than the third, this latter joint being equal in length to the fourth. Thorax subquadrate, scarcely longer than broad, subcylindrical, scarcely constricted on the sides, the anterior angles very slightly prominent, very obtuse; upper surface opaque, impressed at the base with an oblong fovea. Elytra much broader at the base than the thorax, narrowly obovate and attenuated from the middle to the apex in the ♂, more oblong and less attenuated posteriorly in the ♀; convex, transversely depressed below the basilar space, finely punctate-striate, the striæ arranged in double rows, the punctures nearly obsolete over the whole surface of the elytra, being principally visible below the basilar space.

The *male* of this beautiful species may be known from its congeners by its slender elongated hinder thighs; the female, which is nearly equal in size to the male, and therefore probably fully developed, differs in the absence of the spines on the under surface of the hinder thigh.

SAGRA FEROX, n. sp. Elongata, subcylindrica, obscure metallico-olivacea, cyaneo tincta, subopaca, antennis obscure metallico cæruleis; thorace subquadrato, cylindrico, opaco, impunctato, angulis anticis prominulis, obtusis; elytris thorace latioribus, subelongatis, ad apicem attenuatis, supra convexis, ante medium subnitidis, apicem versus opacis, evidenter punctato-striatis, striis gemellatis, apicem versus fere obsoletis.

Mas femoribus intermediis subtus ante apicem spina valida acuta armatis; femoribus posticis corpus valde superantibus, basi fulvo-tomentosis, dorso ad apicem profunde et late canaliculatis, subtus pone medium crista denticulata brevi, et ante apicem spina valida acuta armatis; tibiis ejusdem paris elongatis, gracilibus, infra basin leviter sinuatis, apicem versus introrsum flexis, extus ante apicem crista oblonga, intus tuberculo obtuso instructis. Long. $9\frac{1}{4}$ lin.

Hab. South Africa, Ribé.

Antennæ nearly three fourths the length of the body; the third and two following joints oval, nearly equal in length. Thorax rather longer than broad, its anterior angle only slightly produced, very obtuse; above cylindrical, opaque, impunctate. Elytra much broader at the base than the thorax, subelongate, attenuated from behind the middle to the apex; above subcylin-

drical, the humeral callus prominent, bounded within by a longitudinal groove; surface subnitidous on the anterior disk, opaque behind the middle. Each elytron with ten rows of punctures, approximating in pairs and distinct on the anterior disk, obsolete towards the apex of the elytron; interspaces impunctate, faintly impressed (when seen under a lens) with a few sinuous strigæ.

Separated from the male of *S. bicolor*, the only known species which with it can be confounded, by the armed intermediate thighs and by the stronger punctuation of the elytra.

Genus Megascelis, *Latr.*

Megascelis posticata, n. sp. Elongata, parallela, subcylindrica, sordide fulva aureo micans, pube aurea depressa vestita, pedibus sordide flavis, pectore nigro, abdomine obscure metallico-cæruleo; capite (labro antennisque exceptis) viridi-æneo; thorace piceo tincto, dimidio longiore quam latiore, lateribus ante basin constrictis, dorso deplanato, sat fortiter punctato, utrinque oblique impresso-strigoso; elytris parallelis, apice dehiscentibus, sat fortiter punctato-striatis, interspatiis ante medium rude, pone medium minus evidenter rugulosis, dimidio postico cæruleo-nigro. Long. $3\frac{1}{2}$ lin.

Hab. Pebas, Upper Amazons.

Head rugose-punctate, vertex and neck smooth, nearly impunctate; face between the upper portion of the eyes impressed with a longitudinal groove; clypeus semilunate, its surface nearly covered with two large parallel foveæ, the mesial line distinctly thickened; antennæ nearly two thirds the length of the body, filiform, scarcely thickened towards the apex, entirely fulvous; jaws black. Thorax nearly one half longer than broad, the sides moderately constricted behind the middle. Scutellum trigonate, its apex broadly truncate, its surface rugose-punctate, piceo-æneous. Elytra flattened along the suture, coarsely punctate-striate; interspaces transversely rugulose, the rugæ much finer and less distinct towards the apex. Body beneath more sparingly punctured than the upper surface; last segment of abdomen sinuate at its apex. Hinder thighs slightly thickened; hinder tibiæ thickened towards the apex, the latter armed within with a short stout tooth.

Megascelis femorata, n. sp. Angustata, subcylindrica, cæruleo-nigra, nitida, pube grisea parce vestita; capite thoraceque elongatulo viridi-æneis, antennis (apice albido excepto) pedibusque nigris, femoribus (apice excepto) pallide flavis; elytris nigris, sat fortiter punctato-

striatis, interspatiis lævibus, hic illic ante medium obsolete transversim rugulosis. Long. $2\frac{1}{3}$ lin.

Hab. Amazons. A single specimen, formerly in the collection of Mr. W. W. Saunders.

Head nearly glabrous; vertex and neck shining, nearly impunctate, front finely and remotely, the upper portion of the face more closely and strongly punctured; space between the eyes impressed with a rather deep but ill-defined longitudinal groove; clypeus transverse, bounded on either side by a short deep groove, its surface smooth and shining, impunctate; labrum obscure fulvous; antennæ nearly as long as the body, filiform, not thickened towards the apex, three outer joints white, the rest black. Thorax nearly one fourth longer than broad, sides constricted behind the middle; above cylindrical, slightly but distinctly depressed transversely across the middle of disk; surface smooth, middle of disk nearly impunctate, glabrous, sides sparingly punctured, clothed with a few griseous hairs. Scutellum trigonate, slightly longer than broad, its apex obtusely truncate. Elytra broader than the thorax, parallel, dehiscent at the sutural angle, slightly depressed along the base, regularly punctate-striate; interspaces smooth and shining, impunctate. Hinder pair of thighs moderately thickened.

MEGASCELIS BASALIS, n. sp. Elongata, subcylindrica, pube fulva parcius vestita, subtus fulva, pectore æneo-micante; supra, antennis basi exceptis, fulvo-ænea, nitidissima, tibiis anticis quatuor dorso ad apicem, posticis apice tarsisque nigris; thorace viridi-æneo maculato, paullo latiore quam longiore, dorso complanato, utrinque excavato, pone apicem sparse, basi minus remote punctato; elytris quam thorax multo latioribus, anguste oblongis, parallelis, sat fortiter punctato-striatis, interspatiis transversim rugulosis, rugulis ad apicem fere deletis, utrinque macula ovata baseos metallico-cærulea, callo humerali læte viridi-metallico. Long. $3\frac{1}{2}$ lin.

Hab. Rio Janeiro. Collected by the late Mr. Squire.

Vertex and neck nearly impunctate; upper portion of face sparingly impressed with deep punctures; space between the upper half of the eyes with a fine longitudinal groove, its anterior extremity bifurcate, surface between the bifurcations depressed; clypeus transverse, bounded on either side by a deep oblique groove; its surface nearly impunctate, only a very few punctures being visible at the extreme base; jaws black; antennæ with the three lower joints æneous, the following five black (the others

wanting). Thorax rather broader than long; sides parallel, slightly rounded, slightly constricted before the base; disk distinctly flattened, very faintly depressed across its middle, the depression terminating on each side in a large distinct excavation, the surface of which is stained with metallic green; just in front of the base are also some irregular concolorous markings; upper surface very smooth and shining, sparingly clothed with adpressed fulvous hairs, very distantly punctured behind the apex, rather more closely so towards the base and on the sides. Scutellum trigonate, its apex broadly truncate. Elytra much broader than the thorax, parallel, depressed along the suture, rather strongly punctate-striate; interspaces nitidous, transversely rugulose, the rugæ nearly obsolete towards the apex.

Genus MEGALOSTOMIS, *Lacord.*

MEGALOSTOMIS PLACIDA, n. sp. Anguste oblonga, subcylindrica ♂, magis ovata ♀, fulvo-picea, subtus pube sordide albido-fulva adpressa dense vestita, supra minus dense fulvo-sericea, antennis dilatatis nigris; labro, vertice, oculorum orbitis, thorace basi et apice, elytrorum callo humerali limboque angusto, pygidii apice tarsisque nigro-piceis; thorace subcrebre punctato; elytris leviter rugulosis, minus crebre punctatis. Long. 4–4½ lin. *Mas.* Capite magno, lato.

Hab. Ega, Upper Amazons.

Head rather closely punctured, space between the eyes broadly excavated on either side, the excavations separated by a narrow longitudinal ridge which extends downwards across the clypeus; vertex impressed with a small fovea; antennæ short, three lower joints nigro-piceous, the rest black, the basal joint strongly thickened, rotundate-ovate, the second and third short, equal, submoniliform, the fourth obovate, moderately dilated, the fifth to the eleventh compressed, laterally broadly dilated. Thorax more than twice as broad as long; sides straight, parallel in the ♂, converging in the ♀, slightly sinuate before the middle, the anterior angles acute, slightly excurved; basal margin sinuate on either side the median lobe, the latter produced, obtusely truncate; above transversely convex, somewhat closely punctured, the interspaces between the punctures granulose-punctate; at the base, in front of the median lobe, are three large, shallow depressions, the middle one perpendicular, the lateral ones oblique; surface clothed with adpressed hairs, rather more densely placed on the sides than on the disk. Scutellum large, trigonate, the sides

rounded, the apex acute; upper surface finely punctured, narrowly edged with nigro-piceous. Elytra scarcely broader than the thorax, subquadrate-oblong; sides parallel in the ♂, rather more attenuated towards the apex in the ♀, subcylindrical, rugulose, finely punctured, rather closely covered with pale adpressed hairs. Thighs stained above with nigro-piceous.

Closely allied to *M. luctuosa*; shorter and more robust, paler in colour, the antennæ shorter in the male and more broadly dilated, the elytra more densely pubescent.

Genus Diaspis, *Lacord.*

Diaspis batesi, n. sp. Subquadrata, obscure cuprea olivaceo tincta, granulosa, subopaca, antennis obscure rufis, extrorsum piceis; thorace crebre punctato, dorso valde gibboso, gibbere antice declivi, apice profunde longitudinaliter inciso; elytris profunde rugoso-punctatis, utrinque costa elevata bicurvata a callo humerali ad suturam oblique ducta tuberculisque sex (duobus ante cæteris infra, medium positis) instructis; pygydio longitudinaliter tricarinato. Long. $2\frac{1}{4}$ lin.

Hab. Ega, Upper Amazons. Collected by Mr. Bates.

Head granulose, the vertex closely, the front more distantly impressed with round punctures; clypeus rugulose; labrum rufopiceous; five lower joints of antennæ obscure rufous, the six outer joints thickened, slightly compressed and forming an elongated piceous club. Thorax granulose-strigose, closely covered with round punctures, sides less closely punctured, hinder portion of disk with a strongly raised gibbosity, the anterior surface of which is very oblique; its apex is divided by a broad, deep, longitudinal incision into two strong, longitudinally compressed protuberances, the apices of which are produced slightly backwards. Elytra slightly attenuated towards the apex, the latter truncate; each elytron with an oblique, bicurvate, strongly raised carina, which extends from just within the apex of the strongly raised humeral callus nearly to the middle of the suture; in addition, six elevated tubercles are arranged as follows:—two before the middle (one at the base, halfway between the suture and the humeral callus, the other small, close to the suture, about halfway between the basal margin and the oblique ridge); four others below the oblique ridge, namely:—the first near the suture, longitudinally compressed, and forming a strongly raised elongate tuberosity; the second and third on the middle disk, much less distinct; lastly, the fourth subapical, transversely compressed and much more strongly raised than the

rest. Middle third of lateral margin reflexed. General surface of the elytra coarsely and irregularly rugose-punctate, the rugosities strigose. When viewed in certain lights, the body presents a velvety appearance.

Chlamys memnonia, Lac. (the type of which, formerly belonging to M. Pilate, is now in my possession), has a distinct second scutellum, and belongs to the present genus. *Ch. mœstifica*, Lac., must for the same reason be placed in this genus.

Genus Chlamys, *Knoch.*

Chlamys velutina, n. sp. Anguste subquadrato-oblonga, rufo-picea, opaca, antennis extrorsum nigris; thorace fortiter subremote punctato, medio gibboso, gibbere sat elevato, antice declivi, elevato-reticulato, apice longitudinaliter sulcato, sulco postice utrinque costa irregulari elevata marginato—nigro-piceo, gibbere antice et apice rufo-piceo; elytris rufo-piceis, nigro-piceo (basi excepta) late marginatis, rude rugosis, utrinque tuberculis duobus ante apicem oblique positis costisque elevatis longitudinalibus tribus, harum prima a basi inter callum humerale et suturam ad declivitatem apicalem extensa, sinuata, basi tuberculo compresso acuto instructa, ad apicem magis elevata et in spinam compressam retrorsum spectante abrupte desinente, secunda minus elevata, a basi prope suturam ad paullo infra medium extensa, basi et medio tuberculata, apice costa brevi transversa valde elevata ad cristam primam connexa, tertia brevi, inter callum humerale et costam primam posita, curvata, ad illam costam paullo ante medium connexa, instructis. Long. 2 lin.

Hab. Amazons. Collected by Mr. Bates.

Head opaque, impressed on the vertex with a fine longitudinal groove; eyes deeply notched; jaws pitchy black; antennæ shorter than the thorax, the seven outer joints compressed, the five upper ones black. Thorax rugose, deeply punctured on the sides, the disk strongly gibbose, the anterior surface of the gibbosity oblique, its apex longitudinally sulcate; covered (the front excepted) with irregular raised reticulations which form an irregular longitudinal ridge on either side of the hinder portion of the apical groove. Elytra scarcely broader than the thorax, oblong, convex, rugose, deeply punctured, the punctures on the sides arranged in longitudinal rows; each elytron with three irregularly serrulate longitudinal ridges—one commencing at the base, halfway between the suture and the humeral callus, slightly flexuose, and extending downwards as far as the deflexed apical portion of the elytron, its base armed with a compressed acute tooth, below the middle the ridge gradually increases in height, its apex terminating abruptly

in a compressed tuberosity, the apex of which is directed backwards; the second commences near the scutellum and runs parallel to the suture, terminating a little below the middle of the elytron, at its apex it is connected by a short, strongly raised, transverse costa with the first ridge, at its base and again at its middle it is furnished with a compressed acute tuberosity; the third raised line commences just within the humeral callus, and, curving gradually inwards, unites with the central ridge at about the end of the anterior third of its course; placed obliquely on the outer disk below the middle are two raised tubercles, the anterior one ill-defined, the hinder one strongly raised; parallel to these, placed between the median longitudinal ridge and the suture, is a small oblong tubercle. Pygidium, together with the sides and apex of abdomen, nigro-piceous, the former with a narrow raised median vitta.

CHLAMYS PLACIDA, n. sp. Subquadrata, valde convexa, castanea piceo tincta, opaca, antennis extrorsum nigris; thorace utrinque fortiter punctato, disco modice gibboso, gibbere elevato-reticulato, apice leviter canaliculato; elytris fortiter punctatis, granuloso-rugosis, utrinque carinis longitudinalibus tribus, prima curvata, basi et apice magis elevata, a basi juxta scutellum ad suturam ante medium producta, duabusque flexuosis, a basi fere ad apicem extensis, instructis. Long. $2\frac{2}{3}$ lin.

Hab. Ega, Upper Amazons.

Head opaque, distantly punctured; face broadly excavated longitudinally between the upper portion of the eyes; anterior border of clypeus concave; antennæ much shorter than the thorax, robust, the eight outer joints compressed and dilated, the six upper ones black. Thorax opaque, granulose, impressed, but not closely, with large, deep, round punctures, those on the sides at the base piceous, the basal margin also narrowly edged with piceous; disk gibbose, surface of the gibbosity elevate-reticulate, its apex very obtuse, longitudinally canaliculate; on each side the gibbosity at the base is an oblique depression. Elytra dehiscent at the extreme base, scarcely broader than the thorax, opaque, strongly and deeply punctured, many of the punctures furnished each with a single, very short, sericeous scale; the anterior disk stained with piceous; each elytron with three longitudinal ridges, the first short, curved, arising at the base close to the scutellum, and terminating on the suture before its middle, thickened and subtuberculate both at base and apex; the second commencing on

the basal margin, halfway between the suture and humeral callus, and running downwards and somewhat obliquely inwards as far as the deflexed apical portion of the elytron; the third commences at the base just within the humeral callus, its anterior third curving move strongly inwards than the former one, until it nearly reaches the second ridge, the two on their middle third running nearly contiguous and parallel to each other, being connected by ill-defined transverse costæ; at the commencement of its lower third it diverges, running obliquely outwards, and is lost on the surface of the outer disk nearly at a level with the apex of the second costa; close to the suture, halfway between its middle and apex, is an obtuse tuberosity. Pygidium broadly ovate-rotundate, truncate at the base, plane, deeply punctured, faintly excavated on either side at the base and towards the apex.

Chlamys chinensis, n. sp. Oblonga, convexa, nitida, subtus pallide picea nigro-piceo tincta, subtus nigro-picea; antennis nigris, basi piceis; thorace profunde punctato, lateribus piceo-verrucosis, disco gibboso, gibbere costis irregularibus piceis rete laxum formantibus instructo; elytris profunde punctatis, rete elevato irregulari et tuberculis nonnullis piceis instructis. Long. $1\frac{2}{3}$ lin.

Hab. China. Collected by Mr. G. Lewis.

Head deeply punctured, nigro-piceous, variegated with fulvo-piceous; vertex and front with a slightly irregular space on either side, the median surface concave; antennæ with the seven outer joints compressed and dilated, nigro-piceous, the four lower ones pale piceous. Thorax deeply punctured, covered on either side with large, irregular, pale piceous, wart-like protuberances; disk gibbous, the gibbosity obtuse, covered with coarse, raised, pale piceous rugæ, which form an irregular network on its surface. Elytra strongly punctured, irregularly strigose, and covered with coarse, irregular, strongly raised, pale piceous lines, which anastomose and form a loose network over the surface; here and there at their points of junction they are still more strongly elevated, and form ill-defined tuberosities; one of these, more distinct and transversely compressed, is placed near the suture below its middle; there are also several others strongly raised and well defined near the apex of each elytron.

Chlamys fulvipes, n. sp. Oblonga, convexa, nigra, subnitida, labro, antennis pedibusque fulvis, femoribus posticis fere totis, intermediis subtus, tibiisque extus nigris; thorace opaco, utrinque obtuse tuber-

culato, medio valde gibboso; gibbere laxe elevato-reticulato, apice longitudinaliter canaliculato; elytris subnitidis, rude rugosis, tuberculis compressis nonnullis validis instructis; pygidio tricarinato. Long. 2 lin.

Hab. India.

Head closely punctured, front with a faint longitudinal impression; labrum fulvous; antennæ rather shorter than the thorax, the six outer joints dilated. Thorax opaque, slightly rugose, obtusely tuberculate on either side, disk strongly gibbous, the gibbosity oblique anteriorly, its apex longitudinally canaliculate, loosely elevate-reticulate. Elytra broadly oblong, less opaque than the thorax, coarsely punctured, the interspaces irregularly rugose, more strongly so on the hinder disk; each elytron with a number of raised compressed tuberosities arranged in three longitudinal rows—namely, four close to and parallel with the suture, four others on the line of junction between the inner and outer disks, less defined, and two on the outer disk itself; humeral callus thickened. Pygidium longitudinally tricarinate, the carinæ intersected and united below the base by a transverse costa.

Genus Lamprosoma, *Kirby*.

Lamprosoma tricolor, n. sp. Breviter ovatum, postice attenuatum, valde convexum, subtus cum antennis nigrum, supra plumbeum, capite thoracisque angulis anticis viridi-æneis; clypeo late transversim emarginato; elytris tenuiter punctato-striatis; prosterno oblongo-quadrato, postice paullo attenuato, disco antice leviter concavo, margine antico paullo elevato, medio sinuato. Long. $3\frac{1}{2}$ lin., lat. $2\frac{1}{3}$ lin.

Hab. Amazons, Santarem.

Vertex minutely and sparingly punctured, lower portion of face more strongly punctate; triangular space between the eyes and an oblique line bounding the clypeus on either side faintly excavated; clypeus short, its anterior margin deeply and broadly excavated, the hinder edges of the emargination transverse, nearly straight; labrum brassy green, its front margin obtusely angled, its surface coarsely punctured along the base, the anterior portion excavated, nearly free from punctures. Thorax more than twice as broad as long at the base; sides rounded and converging from base to apex, nearly parallel at the base; upper surface impressed on either side just in front of the median lobe, very finely and distantly punctured. Scutellum metallic green. Elytra finely but distinctly punctate-striate.

Lamprosoma Batesi, n. sp. Breviter ovato-rotundatum, metallico-olivaceum, nitidum, ore antennisque (basi fulva excepta) nigris; corpore subtus, capite thoracisque lateribus rufo-aureis aut æneis; thorace tenuiter, sat remote punctato; elytris tenuiter punctato-striatis; clypeo antice abrupte declivi, leviter concavo-emarginato; prosterno subquadrato, plano, postice sinuato-emarginato. Long. $3\frac{1}{2}$ lin., lat. $2\frac{5}{6}$ lin.

Hab. Upper Amazons.

Head bright rufo-aureous, the extreme vertex olivaceous; surface very finely rugulose, finely but distinctly punctured; face immediately above the clypeus faintly transversely excavated; apical portion of clypeus abruptly incurved, its anterior border concave; labrum black, its anterior surface deflexed, concave, the anterior border obtusely angulate. Thorax more than twice as broad as long; sides converging and regularly rounded from base to apex; basal margin very oblique and feebly bisinuate on either side, apex of median lobe obtuse; upper surface smooth and shining, finely but subremotely punctured; on either side at the base, close to the median lobe, is a shallow depression, the lobe itself slightly reflexed. Scutellum dark metallic green. Elytra finely but distinctly punctate-striate, the interspaces remotely impressed with very minute punctures. Prosternum subquadrate, plane, its sides sinuate, its apex sinuate-emarginate.

Lamprosoma hypochryseum, n. sp. Breviter ovatum, postice attenuatum, valde convexum, nitidum, supra metallico-cæruleum, sæpe viridi micans; corpore subtus, pedibus capite thoracisque limbo apicali angusto angulisque anticis aureis; abdominis lateribus, ore scutelloque nigris. Var. A. Corpus totum (ore scutelloque exceptis) metallico-cæruleum. Long. $3–3\frac{1}{2}$ lin., lat. $2–2\frac{1}{4}$ lin.

Hab. Mexico, Guatemala.

Head granulose, distinctly but not closely punctured; vertex and front impressed with a faint longitudinal groove; anterior margin of clypeus concave-emarginate; labrum black, cupreo-aureous at the base, its anterior surface oblique, concave, its anterior border obtuse. Thorax about twice as broad at the base as long; sides rounded and converging from base to apex; basal margin very oblique on either side, the median lobe angular, its apex obtuse; above transversely convex, very minutely granulose; surface sparingly impressed with very fine punctures, which are larger and more strongly impressed on the middle of the base: in some specimens, on either side the basal lobe is a faint ill-defined

excavation, only visible in certain lights. Scutellum black. Elytra distinctly punctate-striate, interspaces smooth, impressed here and there with very minute punctures. Prosternum oblong-quadrate, its hinder apex sinuate in the middle; surface plane, narrowly concave on the anterior margin.

Lamprosoma cupricolle, n. sp. Subrotundatum, valde convexum, nitidum, subtus cum antennis (harum basi fulva excepta) nigrum; supra rufo-aureum; thorace cupreo, interrupte rufo-aureo limbato; elytris evidenter punctato-striatis. Long. $2\frac{1}{2}$ lin., lat. 2 lin.

Hab. Ega, Upper Amazons. Collected by Mr. Bates.

Head finely but distantly punctured; front impressed with a perpendicular grooved line; clypeus (viewed from the front) deflexed, concave, its anterior margin also concave; its surface granulose, æneous; labrum black, concave-emarginate; under surface of the basal and the whole of the second and third joints of the antennæ obscure fulvous, the remaining joints black. Thorax more than twice as broad as long at the base; sides obliquely converging and slightly rounded from the base towards the apex, more quickly rounded near the latter; basal margin very oblique on either side, the median lobe slightly reflexed, its apex rounded; upper surface impressed on either side just before the median lobe, sparingly and finely punctured; the entire lateral margin, the hinder margin for nearly its whole length, together with the middle of the apical border, narrowly edged with rufo-æneous. Scutellum metallic green. Elytra distinctly punctate-striate, interspaces smooth, impunctate. Prosternum oblong-quadrate, its surface plane.

Lamprosoma amazonum, n. sp. Subrotundatum ♂, ovato-rotundatum, postice attenuatum ♀, valde convexum, igneum nitidum, subtus cum antennis nigrum; thorace minus remote evidenter punctato; elytris evidenter punctato-striatis; clypeo paullo elevato, declivi, antice concavo-emarginato; prosterno late oblongo-quadrato, plano, rugoso-punctato. Long. 3 lin., lat. $2\frac{1}{2}$–$2\frac{3}{4}$ lin.

Hab. Ega, Upper Amazons. Collected by Mr. Bates.

Head finely punctured, its surface somewhat irregular, faintly rugose on the lower face; front impressed with a fine longitudinal groove; clypeus slightly thickened, slightly deflexed, its anterior border concave-emarginate; labrum black, its front margin obtusely angulate, its anterior surface inflexed, concave. Thorax more than twice as broad as long at the base; sides regularly rounded and converging from base to apex; basal margin very

oblique and very slightly bisinuate on either side, median lobe subacute; upper surface distinctly punctured, interspaces (when viewed under a lens) very minutely punctured; at the base on either side the median lobe is a distinct depression. Scutellum narrowly trigonate, shining black. Elytra distinctly punctate-striate, interspaces remotely impressed with very minute punctures, only visible under a lens. Prosternum broadly oblong-quadrate, its surface plane, coarsely rugose-punctate.

Lamprosoma tridentatum, n. sp. Ovatum, postice attenuatum, valde convexum, nitidum, subtus cum antennis nigrum, supra aureo-æneum; capite granuloso, tenuiter subremote punctato; clypeo declivi, antice concavo-emarginato; labro tridentato; thorace remote tenuiter punctato; elytris sat fortiter punctato-striatis; prosterno plus duplo longiore quam latiore, plano, fortiter punctato, antice concavo. Long. 3 lin., lat. $2\frac{1}{4}$ lin.

Hab. Brazil.

Head granulose, finely but not closely punctured; clypeus almost entirely separated from the face by a sutural line, its anterior surface gradually deflexed, more coarsely punctured than the upper face, its anterior margin concave-emarginate; labrum black, its anterior margin tridentate. Thorax more than twice as broad as long at the base; sides quickly converging and slightly rounded from base to apex; basal margin very oblique on either side, broadly but slightly concave near the outer angle, apex of median lobe subacute; upper surface distantly and finely punctured, impressed near the middle of the basal margin with a few large punctures; at the middle of the base, just before the basal lobe, is a faint, ill-defined transverse impression. Scutellum narrowly wedge-shaped, black. Elytra rather strongly punctate-striate; interspaces plane, impressed here and there with faint irregular strigæ.

Lamprosoma canaliculatum, n. sp. Breviter ovatum, gibboso-convexum, late metallico-purpureum, nitidum, pectore oreque nigris; capite evidenter punctato; clypeo depresso, antice profunde concavo-emarginato, sinus lateribus in dentem robustum obtusum, intus leviter curvatum, producto; thorace evidenter subremote punctato, nitido, utrinque ante lobum basalem vix excavato; elytris distincte punctato-striatis, interspatiis (sub lente) tenuissime punctatis; prosterno plus triplo longiore quam latiore, antice canaliculato. Long. 3 lin., lat. $2\frac{1}{4}$ lin.

Hab. Upper Amazons, Pebas.

Head finely but distantly punctured; clypeus and a narrow tri-

angular space above depressed, the former on either side rather more deeply excavated; anterior margin broadly and deeply excavated, angles of the emargination produced into a stout, obtuse, slightly incurved tooth; labrum obtuse, its anterior surface excavated. Thorax more than twice as broad as long at the base; sides obliquely converging and slightly rounded from base to apex; basal margin very oblique and faintly bisinuate on each side, apex of median lobe obtuse; surface faintly excavated on each side just in front of the basal lobe, more strongly punctured than the head. Scutellum metallic green. Elytra distinctly punctate-striate, interspaces here and there faintly impresso-strigose, very minutely punctured, the punctures (visible only under a lens) arranged on each interspace in a broad longitudinal row. Prosternum narrow, elongate; sides elevated in front, the space between forming a deep longitudinal groove; surface coarsely punctured. Legs robust, intermediate tibiæ not more dilated than the hinder pair.

Nearly allied to *L. amesthystinum*; one half the size, more convex, and more attenuated posteriorly.

Lamprosoma cuneatum, n. sp. Ovatum, postice valde attenuatum, valde convexum, subtus cum antennis nigrum, supra læte metallico-purpureum; capite granuloso, viridi-cyaneo, fortiter punctato, facie supra clypeum fovea magna impressa; clypeo plano, antice truncato; thorace sat fortiter minus remote punctato; elytris sat fortiter punctato-striatis, interspatiis remote tenuissime punctatis; prosterno quadrato-oblongo, longitudinaliter concavo, rude rugoso. Long. $3\frac{1}{2}$ lin., lat. $2\frac{3}{4}$ lin.

Hab. Amazons.

Head granulose, coarsely but not very closely punctured; surface of front slightly irregular; face impressed just above the clypeus with a large deep fovea; clypeus almost entirely separated from the face by a deeply impressed sutural line; its surface plane, its anterior border truncate, obsoletely sinuate in the middle; labrum black, impressed at the base with a transverse row of deep punctures; its anterior surface oblique, slightly concave, its anterior margin very slightly emarginate; antennæ as long as the thorax, the five outer joints rather strongly dilated and forming a narrow oblong club. Thorax more than twice as broad as long; sides rounded and obliquely converging from base to apex, flattened along the middle; basal margin very oblique and sinuate on either side, median lobe obtuse; upper surface rather coarsely

but not deeply punctured; on either side the basal lobe is a distinct excavation. Scutellum elongate-trigonate. Elytra very convex, much attenuated towards the apex, the humeral callus prominent; punctate-striate, interspaces sparingly impressed with very minute punctures, outer interspaces faintly convex.

LAMPROSOMA ARMATUM, n. sp. Ovatum, postice attenuatum, valde convexum, subtus nigro-cæruleum, nitidum, supra granulosum, subnitidum, plumbeum, capite æneo-micante, ore antennisque nigris; clypeo antice paullo inflexo, concavo-emarginato; thorace remote tenuiter punctato; elytris evidenter punctato-striatis; prosterno subquadrato-oblongo, postice plano, antice paullo concavo, margine antico utrinque in dentem validum deorsum producto. Long. $3\frac{2}{3}$ lin., lat. 3 lin.

Hab. Columbia.

Head granulose, finely but remotely punctured; clypeus almost entirely separated from the face by a sutural line, its anterior portion incurved, its apex concave-emarginate; labrum black, its anterior surface obliquely depressed, concave, its apex produced into two short obtuse lobes. Thorax more than twice as broad as long at the base; sides converging and moderately rounded from base to apex, slightly flattened on the middle and towards the apex; basal margin very oblique and bisinuate on either side, median lobe distinctly produced, its apex subacute; upper surface granulose, finely and distantly punctured, the puncturing rather stronger at the sides and base; at the base on either side the median lobe is a distinct excavation. Scutellum black. Elytra distinctly punctate-striate. Prosternum nearly twice as long as broad, dilated in front, the anterior margin produced on either side into a strong acute tooth; surface plane, concave in front, distantly punctured.

Genus DORYPHORA, *Ill.*

DORYPHORA VERRUCOSA, n. sp. Rotundato-ovata, valde convexa, niger, subtus nitida, supra opaca, vertice puncto rufo armato; thorace fere impunctato; elytris sat profunde inordinatim punctatis, interspatiis elevatis, verrucosis; nitide fulvis, margine externo angusto limboque inflexo nigris; mesosterni spina valida, quam metasternum paullo longiore. Long. 7 lin.

Hab. Brazil, New Friburg.

Head distantly and remotely punctured; vertex impressed with a longitudinal groove. Thorax more than twice as broad as long; sides straight and nearly parallel from the base to the middle, then obliquely rounded and converging to the apex, the latter

strongly produced, subacute; upper surface slightly excavated on either side, very opaque, nearly impunctate, impressed on either side at the base with a few very minute punctures; lateral margin bordered by a single row of large punctures, which extend, although less strongly marked, along the inner edge of the produced apex. Elytra broader than the thorax, subquadrate-ovate, very convex, deeply punctured, the interspaces thickened and forming irregular wart-like tubercles over the whole surface. Mesosternal spine very stout.

DORYPHORA BUCKLEYI, n. sp. Anguste oblonga, convexa, subtus cupreo-nigra, tibiis tarsisque interdum cyaneo tinctis, supra cuprea, nitida, antennis cyaneo-nigris, extrorsum nigris; thorace rude punctato, interspatiis irregulariter elevato-cicatricosis; elytris quam thoracis basis multo latioribus, apicem versus paullo attenuatis, convexis, pone medium declivibus, sordide fulvis, rude et profunde piceo-punctatis, punctis inordinatis, interspatiis ad apicem et ad latera incrassatis, subverrucosis, fasciis erosis tribus, prima baseos integra, secunda ante medium extrorsum abbreviata, tertiaque vix pone medium extrorsum interrupta et abbreviata, nec non limbo inflexo nigro-æneis. Long. 8 lin.

Hab. Ecuador. Collected by Mr. Buckley.

Head rugose-punctate, interspaces granulose; front impressed with a longitudinal groove, which terminates between the eyes in a deep fovea; antennæ half the length of the body in the male, rather shorter in the female, nigro-cyaneous. Thorax nearly twice as broad as long; sides straight and slightly diverging from the base to beyond the middle, thence rounded and converging to the apex, the latter strongly produced, armed with a small fulvous tooth; upper surface deeply impressed with large round punctures, which are irregularly congregated over the surface; interspaces granulose, elevate-cicatrose. Elytra much broader at the base than the thorax, slightly narrowed towards the apex, the shoulders broadly rounded; above convex, the highest part of the convexity being before the middle, whence to the apex the surface is obliquely deflexed; deeply impressed with large piceous punctures, indistinctly placed in longitudinal rows on the anterior half of the inner disk, placed irregularly over the rest of surface; interspaces on the sides and apex thickened and subverrucose; each elytron with three erose fasciæ, one narrow on the basal margin, a second before the middle, common, broad, attenuated externally, and abbreviated some distance within the lateral margin, and the third rather narrower, more deeply and irregularly erose, abbreviated externally and also on the extreme

sutural margin, nigro-æneous; inflexed limb nigro-cyaneous, longitudinally concave, its outer margin verrucose. Mesosternal spine stout, slightly longer than the metasternum.

Separated from *D. biremis* by the narrow, less convex form and by the coarser punctuation of the thorax and elytra.

Doryphora undulata, n. sp. Oblongo-ovata, convexa, nigra, nitida, pedibus nigro-cyaneis, capite thoraceque subnitidis, hoc tenuiter punctato; elytris sat fortiter punctato-striatis, striis gemellatis, cyaneo-nigris, fasciis angulato-undulatis quatuor, prima baseos interrupta, secunda ante, tertia prope medium quartaque inter medium et apicem magis flexuosa, maculisque ante apicem, inter se et cum fascia apicali confluentibus, flavis; macula marginali pone medium posita rosea; limbo inflexo nigro, tertia parte intermedia punctoque prope basin roseis. Long. 6–7 lin.

Hab. Columbia.

Head opaque; antennæ half the length of the body, the five lower joints nitidous, nigro-cæruleous, the rest opaque black. Thorax twice as broad as long; sides straight and nearly parallel from the base to beyond the middle, thence rounded and converging to the apex, the latter submucronate; upper surface rather finely but distinctly punctured. Elytra oblong, rather strongly punctured, the punctures arranged in double rows, confused on the outer disk; each elytron with four narrow angulose-undulate pale yellow fasciæ, the first at the extreme base, interrupted in the middle and on the outer border, the second between the base and the middle, abbreviated on the suture and at the outer margin, the third across the middle itself, entire, and the fourth halfway between the middle and the apex, abbreviated at the suture, the last very irregular and connected with several irregular concolorous patches, which extend nearly to the apex of the elytron; in addition, on the middle disk of each elytron between the third and fourth fasciæ is a short semilunate yellow line; on the outer margin, just at the outer extremity of the apical fascia, is a small oblong red spot, connected beneath with the concolorous third of the inflexed limb; in some specimens are also several small spots of the same colour, placed near the apex of the elytron. Mesosternal spine strong, nearly equal in length to the metasternum.

Doryphora dorsomaculata, *Jacoby* *. Late oblongo-ovata, valde

* Since this paper was read, Mr. M. Jacoby, in the 'Proceedings of the Zoological Society' for the present year, p. 146, has described this insect under the name given above. My description being already in type, it was too late to withdraw it.

convexa, pallide picea, nitida, antennis extrorsum nigris; thorace sat crebre punctato; elytris sat fortiter punctato-striatis, prasinis, puncto basali, limbo exteriore, plagaque magna communi, a basi fere ad medium extensa, postice rotundato-ampliata, piceis, vittulis duabus basalibus prope suturam lineaque submarginali flavis, sutura pone plagam sordide flava, spina sat valida. Long. 4½ lin.

Hab. Bahia.

Thorax transverse, twice as broad as long; sides rounded, the anterior angles mucronate; disk rather closely punctured, the puncturing varying both in degree and density in different individuals. Elytra regularly punctate-striate, the punctures pale piceous; interspaces impunctate, with the exception of the one between the seventh and eighth striæ, which is impressed about its middle with a few punctures, equal in size to those on the striæ themselves.

Doryphora mœsta, n. sp. Anguste oblonga, convexa, cupreo-nigra, nitida, antennis nigris; thorace irregulariter punctato, angulis anticis mucronatis, mucrone fulvo; elytris sat fortiter punctatis, punctis disco externo inordinatis, disco interno striatim dispositis, striis gemellatis, fulvis, utrinque sutura maculisque sex superficiem fere amplectentibus cupreo-nigris, harum prima baseos postice erosa, secunda elongata apicali ad marginem apicalem adfixa, cæteris irregularibus fascias interruptas duas, unam ante alteram pone medium positas, formantibus; limbo inflexo fulvo, tertia parte apicali cupreo-nigra; spina valida. Long. 6 lin.

Hab. Columbia, Bogota.

Face rather closely punctured between the eyes; antennæ half the length of the body. Thorax more than twice as broad as long; sides nearly straight and parallel, rounded and converging at the apex, the anterior angle mucronate, its apex fulvous; upper surface concave on either side, the surface irregularly punctured. Elytra broader than the thorax, their sides parallel, their apices regularly rounded. Mesosternal spine rather shorter than the metasternum.

Nearly allied to *D. cisseis*, Stål; at once known by its narrower thorax and by its narrower and more parallel form; the markings on the elytra are also much larger, covering nearly the whole of the surface.

Doryphora Jacobyi, n. sp. Ovata, convexa, nigro-ænea, nitida, thorace sat crebre fortiter punctato; elytris confuse gemellato-striato-punctatis punctis disco externo inordinatis, pallide stramineis; limbo angusto, ad suturam magis distincto, fasciisque duabus erosis,

prima ante medium, elytri medio abbreviata, alteraque vix pone medium, integra, paullo obliqua, nigro-cupreis. Long. $5\frac{1}{2}$ lin.

Hab. Ecuador. Collected by Mr. Buckley.

Head rather closely punctured; front impressed with a short longitudinal fovea; antennæ black, the basal joint nigro-cyaneous. Thorax scarcely twice as broad as long; sides straight and parallel from the base to beyond the middle, thence rounded and converging to the apex, the latter produced, armed with a short piceo-fulvous tooth; upper surface excavated on either side, deeply punctured, the punctures irregularly crowded on the inner disk, leaving here and there some impunctate patches. Elytra broader than the thorax, convex, rather finely but distinctly punctured, the punctures arranged in longitudinal rows on the inner disk and on the extreme outer margin of the elytron, these rows approximate, but rather indistinctly, in pairs: on the greater portion of the outer disk the puncturing is confused; the disk of each elytron with five or six obsoletely elevated vittæ; pale yellow, each elytron with a spot at the base near the scutellum; a broad common erose fascia, abbreviated at the middle of the elytron, placed halfway between the base and the middle, and a second entire, also erose, slightly oblique, situated just below the middle, nigro-cupreous; inflexed limb longitudinally concave, black, with a faint metallic tint. Mesosternal spine rather longer than the metasternum.

Genus Labidomera, *Chevr.*

Labidomera imperialis, n. sp. Rotundato-ovata, valde convexa, metallico-purpurea, subnitida, scutello, tarsis antennisque nigris, his basi piceis; thorace opaco impunctato; elytris tenuissime punctato-striatis, punctis in striis confusis, utrinque fascia irregulari pone medium, utrinque abbreviata, pustulisque tribus, prima subrotundata, infra basin prope suturam sita, duabusque prope medium transversim positis, externa transversa, interna subrotundata, læte fulvis ornatis. Long. 5 lin.

Hab. Rio Janeiro. Collected by the late Mr. Squire.

Head smooth, impunctate; front and vertex impressed with a very fine longitudinal groove; clypeus short, its upper margin transverse, its surface slightly concave, finely punctured; antennæ half the length of the body, three lower joints piceous, stained above with black. Thorax more than twice as broad as long; sides rounded, converging in front, anterior angles acute; upper surface opaque, impunctate. Elytra very minutely punctate-

striate, the punctures very irregularly placed on the striæ, the latter obsolete towards the apex; interspaces very minutely granulose-punctate, sparingly aciculate.

Genus DEUTEROCAMPTA, *Erichs.*

DEUTEROCAMPTA SAUNDERSI, n. sp. Ovata, convexa, nigra, nitida; thorace subremote punctato, lateribus latis margineque apicali angusto, medio angulato, flavis; elytris evidenter punctato-striatis, utrinque vitta suturali, basi et apice angustata, maculisque sex, superficiem fere amplectentibus, nigris ornatis; harum duabus communibus, prima pone basin, subcordata, secunda ante apicem, transversim trigonata, tertia subrotundata, ad marginem humeralem adfixa, quarta et quinta prope medium transversim positis, oblongis, externa postice obliqua, ad marginem adfixa, sextaque marginali, minore, ad plagam communem trigonatam parallela. Long. 4 lin.

Hab. Brazil; a single specimen, formerly in the collection of Mr. W. W. Saunders.

Four lower joints of antennæ, together with the palpi, piceous; face excavated and distinctly punctured on either side; middle of front and vertex nearly impunctate, impressed with a fine longitudinal groove; upper margin of clypeus angulate; antennæ slightly less than half the length of the body, the four lower joints piceous, the five outer ones distinctly thickened. Thorax nearly three times as broad as long; sides nearly parallel at the base, rounded and converging in front; disk subremotely punctured, sides impunctate.

The Life-history of *Filaria bancrofti*, as explained by the Discoveries of Wucherer, Lewis, Bancroft, Manson, Sonsino, myself, and others. By T. SPENCER COBBOLD, M.D., F.R.S., F.L.S., Professor of Botany and Helminthology, Royal Veterinary College.

[Read March 7, 1878.]

THE time has now arrived when we may, with profit, pass in review the essential facts of Hæmatozoal discovery in relation to this *Filaria*, and build up, as it were, a complete life-history of one of the most remarkable parasites that has ever engaged the attention of helminthologists. In short, I propose to show the steps by which we have acquired our present knowledge, what that knowledge actually expresses when summarized in the lowest possible number of convenient terms, and what practical consequences may be expected to flow from a fuller recognition of its

importance. The practical issues especially affect the welfare of persons resident in warm countries.

In the year 1868 Dr. O. Wucherer, since deceased, published a paper in the 'Bahia Medical Gazette,' entitled, "Preliminary Notice of a hitherto undescribed Species of Worm encountered in the urine of persons affected with the intertropical hæmaturia of Brazil" (Ref. No. 1*). Dr. Wucherer first discovered this entozoon on the 4th of August, 1866, when engaged in examining the chylous or milky urine of a patient then under his care at the Misericordia Hospital. He was at the time actually in search of the *Bilharzia hæmatobia*. It was at the suggestion of Griesinger that Wucherer sought for this fluke; and when thus engaged he found in its place, so to say, "some filiform worms which were very narrow at one extremity and very obtuse at the other." As will be seen in the sequel, a similar experience afterwards occurred to myself. Dr. Wucherer, with a caution worthy of the true *savant*, did not at once conclude that the urinary parasites had actually passed from his patient; therefore taking the necessary steps to prevent error, he obtained a fresh supply of the excretion in a carefully cleaned vessel, and almost immediately afterwards verified his previous discovery. In the following October, and also subsequently, Wucherer made similar "finds." In two of these three instances the patients suffered from chyluria; and in the third there was hæmaturia. The *Filariæ* were in all cases living and active in their movements. He did not notice any eggs †.

In the year 1869 (when engaged in preparing a supplementary bibliography to my introductory treatise on the Entozoa) I chanced to stumble upon a paper by Dr. Salisbury which had hitherto escaped the attention of helminthologists (Ref. No. 2). In this memoir, published in 1868, Dr. Salisbury announces the discovery of a small species of entozoon in the bladder of a patient who passed milky urine. Dr. Salisbury had the boldness at once to describe the worm as new to science, and placed it in the genus *Trichina* (*T. cystica*, Salisb.). Nothing, I may remark, could be more striking than the difference of attitude assumed

* The numbers here given refer to the Bibliography at the close of this communication.

† Some error as to the date of Wucherer's discovery has crept into the literature of this subject. Thus, in the 2nd edition of Davaine's 'Traité' (p. 943) the year 1868 is mentioned as that in which the original find was made. In this matter I have followed the authority of Dr. Silva Lima.—T. S. C.

by Wucherer and Salisbury respectively. The one *savant* was timid and reserved, almost to silence, respecting his find (which had absolute priority), whilst the other put a totally wrong construction on the facts observed. Dr. Salisbury unhesitatingly relegated these mere embryonal forms to a genus with which there was not a shadow of proof that it was entitled to be associated.

During the month of March 1870, Dr. T. R. Lewis, of Calcutta, noticed that minute Nematoid worms were present in chylous urine. He did not, it seems, publish the fact at the time; but in his Memoirs, which appeared some years afterwards, he distinctly records the circumstance. In October 1872 he repeated his investigation of the urine of one of the patients examined in 1870, and had the satisfaction of finding the young *Filaria*, which "had undergone no appreciable change." He also examined the blood, with results that will appear in the sequel. Dr. Lewis states that Dr. Charles and Dr. Palmer were the first to verify his observations respecting the presence of *Filariæ* in chyluria.

In the month of July 1870, whilst engaged in the examination of the urine of a little girl (who was under my professional care as a sufferer from the Bilharzia disease, which she had contracted at Natal, South Africa), I discovered numerous eggs and embryos of a nematode worm. Although thousands of fluke's eggs passed daily from this child, with much blood, it never occurred to me that the nematodes were hæmatozoal. The circumstance that the child's parent had told me that three small worms had long before passed by the urethra, led me to conclude that they and their probable progeny were alike of urinary origin. Had I examined a drop of blood from the finger, Dr. Lewis's subsequent important discovery of microscopic Hæmatozoa would probably have been anticipated. I do not at all regret that I was thus misled.

It was not until the spring of 1872 that I announced my interesting find (Ref. No. 3). When doing so I did not seek to secure scientific capital by imparting to mere embryos a generic and specific title, but remained content to record the facts observed, at the same time giving simple figures of the worm as seen in the free and egg conditions. The notion which Leuckart has since suggested, that the three mature worms alluded to were Oxyurides, is by no means convincing (Ref. No. 4). As the mother of the child more than once pointed to her finger's length

as indicating to me the length of the worm, I now incline to the opinion that the worms in question were none other than sexually mature examples of *Filaria bancrofti*. This view, moreover, receives strength from the circumstance that I drew long thread-like strokes on paper which, she said, corresponded in appearance with the worms. As to the thickness of the worms, nothing reliable was said. When I wrote the original paper I had no knowledge of the fact that Wucherer had anticipated Salisbury's previous discovery by about two years.

In and about the year 1872 several 'finds' of a similar order to those above announced were made in foreign countries. I regret that I cannot fix the dates of all these verifications with absolute precision. In September 1872 Dr. Corre published a "Note respecting the helminth encountered in hæmatochylous urine" (Ref. No. 5). His careful description clearly refers to the same entozoon as that already described by Wucherer, by Salisbury, and by myself. Again, in a communication addressed to Dr. Davaine, and quoted in the recently published 2nd edition of his (Davaine's) well-known work, Dr. J. Crevaux refers to a hæmaturia patient of his, at Guadeloupe, from whose urine he had frequently obtained small worms (*vers de la Guadeloupe*). He had, however, more than a hundred times punctured his patient for the purpose of examining fresh blood; but in no single instance did he detect microscopic Hæmatozoa (Ref. No. 6). If I understand rightly, Corre's description refers to worms obtained from this selfsame patient.

In Dr. Crevaux's remarks especial reference is made to a joint memoir previously published by Dr. da Silva Lima and himself (Ref. No. 7). Dr. Crevaux adds that although Dr. Lima diligently sought for hæmatozoa in five separate patients whose urine contained numerous worms, yet in no instance were any entozoa found in the blood. Notwithstanding the recorded differences as between the "*vers de la Guadeloupe*" described by Crevaux and Corre and the "*vers du Brésil*" described by Wucherer and Silva-Lima, I can see no valid reason for supposing that they are not identical forms.

In this place must also be noticed a very interesting circumstance recorded by Robin (Ref. No. 8). He says that Dr. Foncervines transmitted to him the history of a case of chyluria affecting an officer residing at Réunion Island. In this case some blood-clots taken from the urine were found to contain embryonic

Nematodes. Two years subsequently, the dried clots being softened in water, were still found to contain the worms tolerably well preserved. From the date of the publication of Robin's 'Lectures,' Dr. Foncervines's 'find' could not, I presume, have been made later than 1872. Not improbably it occurred at an earlier date. M. Robin gives a figure of one of the worms. The length and thickness of it do not materially differ from the measurements of the Guadeloupe worm as given by Dr. Corre. I hold that the slight discrepancies which do exist in respect of size are of little or no moment. Stages of growth are alone sufficient to account for some of them. The presence of an outer skin, which some have spoken of as a cyst, cannot be held either to settle or even to influence the question of specific identity. The outer envelope, so far from its being in any sense comparable to an adventitious cyst or "sheath," as Lewis calls it, actually represents the original embryo-skin separating by ecdysis. Its nature ought to have been recognized from the very first; but Lewis appears to have thought that the presence of "delicate, translucent sheaths" indicated a material departure from the appearances commonly presented by "the young of many other Nematodes."

Early in the month of July 1872 Dr. Lewis made his interesting discovery of Nematode Hæmatozoa in the blood of an Indian native suffering from diarrhœa; and in the month of October of the same year he detected microscopic *Filariæ* in the blood of one of the patients in whose urine he had detected similar worms more than two years previously. This is the case I have previously quoted. Without repeating any details, it suffices to remark that the urinary parasites and the Hæmatozoa were identical. Dr. Lewis, recognizing the importance of his discovery, named the larval parasite *Filaria sanguinis hominis* (Ref. No. 9). Of course it was not possible for Lewis to declare that his embryonal nematoids must belong to the genus *Filaria*, since the embryos of other nematode genera very closely resemble these microscopic hæmatozoa. However, the proposed nomenclature, so far as the genus was concerned, turned out to be a 'lucky hit.'

The subsequently discovered parent worm may fairly be relegated to the genus in which Lewis thus happily placed it. We now know, or at least are fully persuaded, that the larval worms first discovered by Wucherer are identical with those separately

found by Lewis, Salisbury, Crevaux and Corre, da Silva Lima, Foncervines, and myself. If, therefore, the original discoverer's name must stand in connexion with the genus *Filaria*, the worm in question ought, in all fairness, to be permanently recognized as *Filaria wuchereri*. I hold, however, that in the present case the parasite of Wucherer, of Salisbury (who placed it in the genus *Trichina*), and of others (who either, like myself, did not choose to give it a special name, or who, like Salisbury, adopted an erroneous nomenclature) should carry with it the name of the person who was the first to discover and to describe the sexually mature representative of the hæmatozoa. Such a recognition can in no way detract from the supreme merits of Lewis. In the next place it does no injury to Wucherer's priority in the matter of the original discovery of the larva. In the third place no injustice is done to Manson, whose remarkable discovery of the intermediate host places the fame of his research on an equally secure basis. In short, the helminthologist of the future, when dealing with the question of the discovery of this entozoon, will find himself obliged to bracket the names of four distinguished observers together. Would he seek to be disinterestedly just, he must also award more or less conspicuous merit to the several other workers whose names will naturally be read between the lines that record the discoveries of Wucherer, Lewis, Bancroft, and Manson.

In this connexion the 'finds' of Drs. Sonsino, O'Neill, Araujo, and Felicio dos Santos cannot be passed over. It was on the 1st of February, 1874, that Sonsino detected microscopic *Filariæ* in the blood of a young Egyptian Jew (Ref. No. 10). He records the fact in the following words :—"I put a drop of blood (from the finger of the boy) under the microscope, placing it directly under the objective glass, when with astonishment I discovered a living organism in the midst of the hæmatic globules. The nematoid had the shape of an *Anguillula*, as fig. 6 (in Dr. Sonsino's memoir) represents. It glided amongst the blood-globules, which were tossed to and fro by its lively movements." Dr. Sonsino verified his observation on the 6th of the same month; nevertheless, neither himself nor his colleagues (Drs. Ambron, Dacorogna, Dutrieux), nor Dr. Abbate Bey, to all of whom the facts were demonstrated, could at first persuade themselves that the worms had really come from the blood. It was not until Sonsino had become acquainted with the facts that I had recorded

in respect of my little hæmaturic patient from Natal that he was fully satisfied as to the genuineness of his 'find' and as to the identity of the parasitic forms in question.

In the year 1875 Dr. O'Neill found similar or, to use Dr. Silva Lima's words, "the same microscopic *Filariæ* proceeding from the skin affected with a disease peculiar to negroes, and which they called 'craw-craw.'" About the same time Dr. Araujo also encountered this *Filaria* in a negro at Bahia suffering from the same disease. Dr. Araujo named the worm *Filariose dermathemica* (Ref. No. 11). It is worthy of remark, in passing, that in the 'craw-craw' cases the persons affected were not chyluric. Further in this connexion, and in support of the parasitic theory of hæmatochyluria, Dr. Silva Lima refers to the writings of Dr. Almeida Couto (Ref. No. 12), and also, especially, to an inaugural thesis by Dr. Victorino Pereira. This distinguished young physician divided the hæmaturic discoveries into four epochs, which he severally termed (1) the unknown, (2) the Egyptian, (3) the Brazilian, and (4) the Indian period. To these, however, as Dr. Silva Lima and myself have pointed out, must now be added (5) the Australian, and (6) the Chinese epochs of discovery (Ref. No. 13).

The part which I took in connexion with the Australian 'finds' requires explanation. In 1876 Dr. Bancroft announced his discovery of microscopic Hæmatozoa. He sent some of the human blood in capillary tubes to Dr. Roberts, of Manchester, who forwarded part of them to myself, and we verified the facts. In the contents of one of the tubes I happened to notice a single, empty, and uninjured egg-covering; and as this corresponded in size and shape with some of those I had obtained from my Natal patient (1870), I drew Dr. Bancroft's attention to the circumstance (Ref. No. 14). This induced Bancroft to search for the parent entozoon in the human body. His search proved successful, as he obtained the adult *Filaria* from a lymphatic abscess of the arm on the 21st of December, 1876. On the 20th of the following April, 1877, he communicated to me the particulars of his investigation, and I announced his discovery in the following July (Ref. No. 15). This announcement appears to have stimulated Lewis to still further efforts, who, it appears, for "the last five years had availed himself of every opportunity that presented itself" for a search after the parent worm. At length Lewis was rewarded, and on the 7th of August, 1877, he found two

mature *Filariæ* in a blood-clot from a young Bengalee (then under Dr. Gayer's care for scrotal disease). Without loss of time Lewis followed up his 'find' by a series of very careful microscopic observations, and at once forwarded an elaborate account of his work to England (Ref. No. 16). Meanwhile Dr. Bancroft had forwarded some specimens of his adult entozoa to myself, together with some rather imperfect illustrations which he had executed and caused to be engraved. Some weeks elapsed before I found time to examine the worms. When at length I did so, and drew up a brief account of the structure and characters of the parasite, I forwarded it to the 'Lancet' office, where, by a singular coincidence, it arrived (as I understand) a few days after the date of the receipt of Lewis's communication. Thus our accounts of the same parasite, under different names, were published almost simultaneously (Ref. No. 17). If our illustrations be compared it will readily be seen that they refer to one and the same entozoon.

I may observe that Dr. Beale (having reproduced my figures and description in the fourth edition of one of his works) had thought it necessary to suggest an amount of ignorance on my part which, had I really displayed it, must certainly have been very reprehensible. Dr. Beale, mixing up two totally distinct parasites (*Filaria sanguinolenta* and *F. sanguinis hominis*) together, has sought to make it appear that I was unaware of the previous discovery by Lewis of the latter worm in the person of the former (Ref. No. 18). Dr. Le Roy de Méricourt has also very courteously reproduced my figures in connexion with the editorial remarks appended by him to the French version of Dr. Silva Lima's memoir (Ref. No. 19).

Here I am naturally led on to observe that notwithstanding the fairly exhaustive character of Silva Lima's memoir, very little account has been taken, either by Lima himself or by other writers, of Manson's earlier investigations. This need not excite astonishment, since few people can have had access to the journal in which Manson's original papers appeared. The 'Customs' Gazette' is little known; and but for the republication of Manson's writings in one of our professional periodicals they might long have remained unnoticed on the Continent (Ref. No. 20). Even now I cannot give the precise date of Manson's earliest paper; but in his Report published in the spring of 1877 (that is, in No. 13 of the 'Customs' Gazette') he refers to earlier papers

by himself in Nos. 10 and 12 of the same periodical. No doubt it was a feeling of isolation that at length induced Dr. Manson to make me the instrument of bringing his later researches before the public; and I think it only fair to Manson that I should quote an extract from his letter to me (dated Amoy, November 27, 1877). He says, "I live in an out-of-the-world place, away from libraries, and out of the run of what is going on, so that I do not know very well the value of my work, or if it has been done before, or better." Those parts of Dr. Manson's voluminous manuscript which give clinical details were forwarded to the English periodical that first made the profession acquainted with his writings (Ref. No. 21), whilst that part of the MS. which deals with the more distinctly helminthic aspects of the question are now submitted to the Society's hands. Other sections of the MS. remain in my hands. These deal with statistics and pathology.

Amongst the other communications to which it is necessary that I should refer, is one by Dr. Pedro S. de Magalhães. Dr. Magalhães describes free Nematodes from the waters of Rio (Agua da Carioca); but notwithstanding their similarity to the larvæ of our *Filaria*, I cannot regard them as having any genetic relation with *F. bancrofti* (Ref. No. 22). I may add that Drs. Chassaniol and Guyot mention the case of a chyluria patient, thirty years a resident at Tahiti, in whom they observed "the parasite, which in all respects resembled that described by MM. Wucherer and Crevaux" (Ref. No. 23).

From what has now been stated it must be obvious to any unprejudiced person that (as in the parallel case of *Trichina spiralis*) if it be asked who discovered *Filaria bancrofti*, the answer must be framed according as to whether the inquirer refers to the adult worm, to the embryonal forms, or to the intermediate larva. To quarrel over the mere name of the parasite would be childish, and serve only to bring upon helminthologists a repetition of the criticism which Helmholtz has recently bestowed upon the conduct of naturalists generally. I have partly stated the reasons why I think Bancroft's name is most fittingly associated with this parasite, and why it should supersede the nomenclature proposed by Lewis (*Filaria sanguinis hominis*). Apart from its trinomial character, in itself an objection, the adoption of Lewis's nomenclature practically ignores the earlier discoveries of Wucherer and Salisbury; yet, from the pathological standpoint,

the name of Lewis will henceforth tower above all others in this connexion, and Bancroft would, I am sure, be the last to dispute the well-earned prerogative of Lewis. If my record is approximately correct, the dates of discovery will stand pretty much as follows:—

1. Wucherer, 1866.—Probably embryos of Strongylidæ (Leuckart); Vers du Brésil (Wucherer; Davaine); *Filaria wuchereri*, suggested, conditionally, in this memoir (Cobbold).

2. Salisbury, 1868.—*Trichina cystica* (Salisbury); nematode eggs and embryos (Cobbold).

3. Lewis, 1870.—Worms that seem to belong to the *Filaridæ* (Busk).

4. Cobbold, 1870.—Embryos of a minute nematode supposed to infest the urinary passages.

5. Crevaux and Silva Lima, 1871 (?).—Vers de la Guadeloupe (Crevaux; Davaine).

6. Corre, 1872.—L'helminthe dans les urines hématochyleuses (Corre).

7. Lewis, 1872.—*Filaria sanguinis hominis*; hematozoon (Lewis).

8. Foncervines, 1873 (?).—Les embryons d'un ver nematoïde (Robin).

9. Sonsino, 1874.—Un nematode microscopico a guisa di Anguillula (Sonsino).

10. O'Neill, 1875.—*Filariose dermathemica*, from craw-craw (O'Neill; Silva-Lima).

11. Manson, 1875 (?).—*Filaria* worm in connexion with chyluria, &c. (Manson).

12. Bancroft, 1876 (spring of). *Filariæ* from human blood (Bancroft; Roberts; Cobbold).

13. Bancroft, 1876 (winter of).—*Filaria bancrofti* (Cobbold).

14. Lewis, 1877.—*Filaria sanguinis hominis*; mature (Lewis).

15. Da Silva Lima, 1877.—Filaire de Wucherer (Silva Lima; Dr. Le Roy de Méricourt).

16. Manson, 1877.—*Filaria sanguinis hominis* (Manson).

17. Manson, 1878.—*Filariæ* in the stomach of Mosquitos (Manson); the higher larval states of the *Filariæ* of Wücherer, Lewis, and Bancroft (Cobbold).

The above is the nearest approximation to a correct chronological record that I can offer. With one or two exceptions the dates refer to the actual periods of discovery. In the exceptional

instances they refer to the time of publication. I can hardly suppose, notwithstanding the pains I have taken, that it is altogether free from error. Be that as it may, the leading features of the record must, I think, be allowed to pass unchallenged; and if so, the following six propositions will likewise be accepted as correct:—

1. *Filaria bancrofti* is the sexually mature state of certain microscopic worms hitherto obtained either directly or indirectly from human blood.

2. The minute hæmatozoa in question, hitherto described as Wucherer's *Filariæ*, *Filaria sanguinis hominis*, *Trichina cystica*, *Filariose dermathemica*, and so forth, are frequently associated with the presence of certain more or less well-marked diseases of warm climates.

3. The diseases referred to include chyluria, intertropical endemic hæmaturia, varix, elephantiasis, lymph-scrotum, and lymphoid affections generally, a growth called *helminthoma elastica*, a cutaneous disorder called craw-craw, and also, not improbably, leprosy itself.

4. It is extremely probable that a large proportion or, at least, that certain varieties of these affections are due to morbid changes exclusively resulting from the presence of *Filaria bancrofti* or its progeny within the human body.

5. It is certain that the microscopic hæmatozoa may be readily transferred to the stomach of blood-sucking insects, and it has been further demonstrated that the digestive organs of the mosquito form a suitable territory for the further growth and metamorphosis of the larval *Filariæ*.

6. The character of the changes undergone by the microscopic *Filariæ*, and the ultimate form assumed by the larvæ whilst still within the body of the intermediate host (*Culex mosquito*), are amply sufficient to establish the genetic relationship as between the embryonal *Filaria sanguinis hominis*, the stomachal *Filariæ* of the mosquito, and the sexually mature *Filaria bancrofti*.

Finally, it remains for me to glance at the practical consequences that may be expected to flow from the acceptance of these conclusions.

One of the greatest hindrances to the due recognition of the remarkable part played by parasites in the production of human endemics and animal epizootics arises from the circumstance that no inconsiderable number of minute worms may infest a host

without obvious injury to the bearer. This immunity, in reality, proves nothing. If, for example, we take the parallel case of *Trichina* we find that several millions of entozoa may exist in the human or, at all events, in the animal bearer without the production of any palpable symptom of discomfort. In such cases it is not possible to determine the strict limits of health and disease; nevertheless, were we to double the amount of infection, an imaginary line of demarcation is at once bridged over, and the parasites become acknowledged as directly responsible for grave symptoms which may even prove fatal to the bearer. Again, the relative strength and size of the infested host constitute factors that will materially modify or limit the power of the parasite for injury. Where the entozoa are of minute size, and where their injurious action is primarily due to the mechanical obstructions they set up, it is clear that the virulence of the helminthiases, or resulting diseased conditions, will mainly depend upon the number of intruders.

Another consideration of the highest value in relation to epidemiology generally, and more especially in regard to the practical question as to the best methods of stamping out parasitic plagues, is that which refers to the life-history of the entozoon itself. It must be obvious that in all cases where the intermediate host can be captured and destroyed, the life-cycle of the parasite can be broken or interrupted; and if thus broken there is an end to the further propagation of the species. The knowledge that we have acquired by experimental research in this connexion has already enabled us to set a limit upon the prevalence of certain well-known disorders, such as trichinosis, cestode tuberculosis, and so forth. In the case of epizootics, however, which are not merely dependent upon minute entozoa, but which are also, in the way that we have seen, indirectly due to the action of intermediary hosts that cannot be readily captured or destroyed, our power of arresting the disease is comparatively limited. In the case of *Filaria bancrofti* it is probably not necessary either that a dead or living mosquito should be swallowed to ensure infection; but it *is* necessary that the parasitic larvæ should have dwelt within the mosquito in order to arrive at the highest stage of larval growth prior to their re-entrance within the human territory. Undoubtedly the larvæ of *Filaria bancrofti* are swallowed with potable waters. The perfect filtration of these waters before use would certainly check and, in course of time, would pro-

bably cause the total extinction of several of the many virulent diseases that now afflict the inhabitants of warm climates.

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12. Couto, A. Gazeta Medica da Bahia, 1877 (Jan. & Feb.), quoted by Silva Lima (*l. c.* p. 444).

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17. Cobbold, T. S. On *Filaria bancrofti*.—The Lancet, Oct. 6, 1877, p. 495 (with figs.).

18. Beale, L.—The Microscope in Medicine, 4th edit. London, 1878 (p. 505). See also D. H. Gabb, below.

19. Méricourt, A. Le Roy de.—Archives de Médecine Navale, Dec. 1877 (p. 448).

20. Manson, P. Report on Hæmatozoa, in the 6th part of the Customs' Gazette, No. xxxiii. Jan.–March: Shangae, 1877.

21. Manson, P.—Chinese Hæmatozoa (thirty-five cases).—Medical Times & Gazette, March 2 and 10, 1878 (pp. 220 and 249); also additional particulars of a Case, Med. T. & G. for March 23, 1878 (p. 304).

22. Magalhâes, P. S. de.—O progresso Medico de Rio de Janeiro,

Nov. 15, 1877; letter in Gazeta Medica da Bahia, December 1877. See also Bourel-Roncière's Analyse, &c. in Archives de Médecine Navale for March 1878, p. 208 (quoted below).

23. Chassaniol, A. et F. Guyot.—Hématurie graisseuse ou chyleuse; in their "Quelques Notes de Géographie Médicale recueilles a Taïti," Archives de Méd. Navale, Jan. 1878 (p. 65).

Appendix (August 1st, 1878).

Since this communication was read, several additional memoirs and papers have come to my knowledge, as undermentioned.

24. O'Neill, J. On the presence of *Filaria* in Craw-Craw.—The Lancet, Feb. 20, 1875 (with figs. p. 265). See also Archives de Méd. Navale, vol. xxiv. p. 229 (from Revista Med. da Rio de Janeiro), and Arch. for March 1878 (p. 204).

25. Coles, G. C. On Lymph Scrotum.—Path. Soc. Rep. in British Med. Journ. for March 9, 1878; also in 'The Lancet' (same date).

26. Bourel-Roncière. Pathologie Exotique. This is an analysis and commentary, chiefly of Dr. Silva Lima's second memoir (Gaz. Med. da Bahia, Nov. 1877), including a case by Dr. Silva Araujo. Many references are given. Archives de Méd. Navale, March 1878, pp. 200–215.

27. Da Silva Lima. The late Dr. Wucherer and the *Filaria bancrofti*. Letter in reference to an article entitled 'Helminthological work in 1877.'—The Lancet for March 23, 1878, p. 441 (dated Bahia, Feb. 26).

28. Cossé. Sur l'Helminthe rencontré par Wucherer et Crevaux, &c. —Revue Montpellier, i. p. 190.

29. Manson and Cobbold. On *Filaria sanguinis hominis* in reference to Elephantiasis, Chyluria, and allied Diseases.—Rep. of the London Medical Society's Proceedings for March 25, 1878, in 'The Lancet' for March 25, 1878 (p. 465).

30. Cobbold. Mosquitoes and Human *Filariæ*.—Clinical Memorandum, in 'British Medical Journal' for March 16, 1878 (p. 366). See 'Popular Science Review' for April 1878.

31. Gabb, D. H. Letter announcing the occurrence of *Filaria sanguinis hominis* at Hastings.—The Lancet for June 22, 1878.

32. Sonsino, P. Sull' *Anchylostoma duodenale* (giving a differential diagnosis as between its embryos and those of *Filaria*). Benha, May 16, 1878. Estr. dall. Imparziale.

33. Lewis, T. R. Remarks regarding the Hæmatozoa found in the Stomach of *Culex mosquito*.—Proceedings of the Asiatic Society of Bengal for March 1878, p. 89.

34. Cobbold, T. S. Letter concerning *Filaria sanguinis hominis*, in 'The Lancet' for July 13, 1878, p. 64. See also 'Midland Naturalist' for August 1878.

On the Anatomy of the Elk (*Alces malchis*).

By Prof. MORRISON WATSON, M.D., and A. H. YOUNG, M.B., Owens College, Manchester. Communicated by Dr. MURIE, F.L.S.

[Read December 20, 1877.]

(PLATES VI. & VII.)

FOR the opportunity of examining the anatomy of the Elk we are indebted to the kindness of Messrs. Jennison, of the Zoological Gardens, Manchester. The structure of this animal, so far as we have been able to ascertain from a reference to such books as are at our disposal, appears to have been very imperfectly worked out. Indeed, with the single exception of a paper by Perrault *, in which only the most obvious points in the anatomy of the organs of digestion and circulation are referred to, we have been unable to discover any anatomical description whatever of this aberrant species. The dissection was commenced with the intention of drawing up a complete account of the anatomy of the animal; and had the period of the year been favourable, this would certainly have been done. Coming, however, as the subject did, into our hands in the month of August, we soon found that decomposition advanced so rapidly that we were compelled to abandon this intention, and, after placing the viscera in spirit, to confine ourselves to the muscular anatomy of the limbs, trusting at some future time to be able to supplement the fragmentary notes which form the subject of the present communication. These notes, however, appear, so far as they go, to contain observations which have not hitherto been published, and we therefore venture to place them on record without further apology.

ORGANS OF DIGESTION.

Tongue (Pl. VI. fig. 1).—The tongue is broader and more flattened toward the tip than is usual among the Cervidæ. Its base for a distance of 3 inches in front of the hyoid bone is smooth and devoid of papillæ, which begin to make their appearance on the dorsum radicis (*Zaglas*). The papillæ vallatæ are small, and are confined to the borders of the tongue in the neighbourhood of the root; they do not extend further forward than the dorsum radicis. The rest of the upper surface of the tongue,

* Mémoires de l'Académie royale des Sciences, Paris, 1733.

as well as the margins, are covered with conical papillæ which are of uniform size, except on the dorsum radicis, where they are larger than elsewhere. Interspersed among these are the fungiform papillæ, which are readily distinguished by means of their white colour. They are placed about $\frac{1}{4}$ inch apart, and are found in greatest abundance on the margins and tip of the tongue, being of smaller size and more closely aggregated in the latter situation.

Cheek.—The buccal mucous membrane is provided with numerous large papillæ (Pl. VI. fig. 2) which, for the most part, are compound, although some are simple in character. The number of secondary papillæ in connexion with a primary papilla is commonly three, although it is not unusual to meet with only two secondary papillæ attached to a common base. Tertiary papillæ may or may not be present; when present, they are small in size, and their number is extremely variable.

Stomach.—The rumen consists of a number of pouches, and does not differ much in respect of form from the ordinary Ruminant type. The mucous lining is covered throughout with papillæ (Pl. VI. fig. 3), which are largest in the hollows of the pouches, but are not wanting on the ridges which separate these, although here they are much reduced in size. The papillæ are, for the most part, spatulate; but interspersed amongst these are many of a cylindrical form. The largest measure between a fourth and an eighth of an inch in length.

The reticulum is large. Its mucous membrane is thrown into ridges which bound hexagonal spaces. These are largest in the centre, and diminish in size towards the extremities of the compartment. The ridges do not exceed $\frac{1}{16}$ of an inch in depth. Numerous papillæ are placed on their free margins, and are found also on the floor of the spaces which they bound.

The psalterium is small. Its mucous coat is thrown into longitudinal laminæ which are arranged in three series: the primary laminæ of this stomach measure $1\frac{1}{2}$ inch in breadth; the secondary laminæ, situated one on either side of the primary, measure 1 inch in breadth; and the tertiary laminæ not more than $\frac{1}{8}$ of an inch. On either side of each tertiary lamina is a row of partially coalescent papillæ, which gives rise to a fourth series of laminæ. The different laminæ decrease in depth towards the extremities of the psalterium; and the surfaces of all of them are covered with sparsely distributed rudimentary papillæ. Adopting

Prof. Garrod's* method, the accompanying diagram will indicate the arrangement of the laminæ.

Diagram showing laminar arrangement of mucous membrane of psalterium.

The abomasum presents the usual form. Its mucous lining is, for the most part, smooth, but close to its commencement is thrown into irregular rugæ. At the pylorus the walls of this compartment are much thickened.

Small Intestine.—The duodenum measured 2 feet in length, and was dilated into a kind of pouch immediately beyond the pylorus. The whole length of the small intestine, including the duodenum, was 43 feet 11 inches. In Perrault's† specimen it measured 48 feet.

Large Intestine.—The cæcum measured $22\frac{1}{2}$ inches in length; according to Perrault‡ 13 inches. Its mucous lining just below the opening of the ileum is thrown into a number of small glandular pouches closely resembling the ileo-cæcal gland of the Giraffe as described by Cobbold§. The pouches, however, are smaller in size in the Elk than in the Giraffe. The rest of the large intestine is arranged in numerous coils, and measures, exclusive of the cæcum, 42 feet 6 inches in length. It diminishes slightly in diameter as far as the rectum, where it is again slightly dilated.

Liver (Pl. VI. fig. 4).—This measures 17 inches from side to side, and $9\frac{1}{2}$ from above downwards; according to Perrault, 1 foot by 7 inches. It is divided into two lobes, right and left, although, as remarked by Perrault, the longitudinal fissure is but feebly pronounced. On the posterior surface of the right lobe is a well-developed caudate lobule of a triangular shape, which lies to the right of the portal fissure, whilst the upper border of the right lobe is prolonged into a triangular Spigelian lobule measuring $\frac{3}{4}$ of an inch in length. The gall-bladder, as remarked by Perrault, is absent.

The *spleen* is elongated oval in form, and measures 8 inches in length and $5\frac{1}{2}$ inches in breadth—measurements which agree with those of Perrault.

* Proc. Zool. Soc. Lond. 1877.

† Mém. de l'Acad. des Sciences, Paris, 1733.

‡ *Loc. cit.* § Todd's Cycl. of Anatomy, vol. v.

Larynx and Circulatory Organs.

The Larynx (Pl. VI. fig. 5), as will be seen by a reference to the accompanying sketch, in its outward features resembles that of the Cervidæ in general. With regard to its cartilages, these have been already described and figured by Professor Owen *.

The Heart is small, and does not differ in respect of form from that of most Ruminants. Its cavities and valves are arranged in the usual manner. The trunk of the aorta divides, as in other Ruminants, into two, anterior and posterior. The "anterior aorta" passes forwards to be distributed to the head, neck, and fore limbs; whilst the "posterior aorta" supplies the trunk and posterior extremities.

Urinary and Generative Organs.

Kidney.—This is smooth and non-lobulated, a fact previously observed by Perrault (*loc. cit.*). The uriniferous tubules open, not on separate papillæ, but upon a single elongated ridge. In this respect the Elk agrees with the larger Cervidæ.

Testicle and Accessory Parts (Pl. VII. fig. 6).—The testicle (*a, a*) is of the usual form, and is provided with a well-marked epididymis. The scrotum is non-pendulous. The vas deferens (*b, b*) measures 18 inches in length, and is slightly dilated at its entrance into the urethra. Before passing through the wall of this canal, the two vasa are closely applied to one another; they terminate on the floor of the urethra in a manner to be presently described. Connected with the posterior extremity of each vas deferens, previous to its passage through the urethral wall, is a small vesicula seminalis (*c, c*), which measures 1¼ inch in length. It is placed along the outer side of the corresponding vas, and is uncovered by muscular fibres. Each unites with the vas of the same side to form the ejaculatory duct.

Lying between the bladder and rectum is a well-marked fold of peritoneum, which consists of two layers, one of which is reflected from the lower aspect of the rectum, and the other from the upper surface of the bladder to become continuous at the free margin of the fold, which is directed forwards. Lying between the laminæ of this fold are the two vasa deferentia and a well-marked vesicula prostatica. The former extend from without inwards, lying in the free margin of the fold, and, having reached the middle line,

* 'Comparative Anatomy of Vertebrates,' vol. iii. p. 594.

pass backward to open into the urethra, whilst the latter lies between the lower extremities of the vasa, and consists of a body and two cornua. The body is represented by a stout fibrous cord, which extends forwards to the free margin of the recto-vesical fold of peritoneum, a distance of 5 inches, where it divides into the cornua. Each of the latter passes outwards in the free margin of the fold for a distance of 3½ inches, and then dwindles into a fibrous cord of such tenuity that it becomes lost in the peritoneum. The body of the male uterus close to its junction with the urethra is united with the vasa deferentia, and diminishes in thickness to the junction of the cornua, where it expands into a mass of tissue of a triangular form. The male uterus is solid, and presents no trace of a cavity except just at its entrance into the urethra, where there is a slight depression of the mucous surface of that canal. There is no trace of a prostate gland.

The intrapelvic portion of the urethra (Pl. VII. fig. 7) measures 3 inches in length. Its walls (*a*, *b*) are thick, and consist of an external coat of circularly arranged muscular fibres, internal to which is a thick layer of erectile tissue. On slitting open this canal an elongated eminence (the veru montanum) is seen to extend from the neck of the bladder to within half an inch of the bulb of the urethra, where it gradually disappears. On the summit of this eminence is the elongated slit-like aperture of a cavity measuring ¼ of an inch in depth, on the floor of which are seen the openings of the ejaculatory ducts. There is no trace of any aperture communicating with the fibrous cord, which represents at least a portion of the uterus; and the question whether we ought to regard the walls of the cavity itself as the representative of, and homologous with the uterus or with the vagina of the opposite sex must in the mean time be left undecided. Leuckart* directs attention to the structure of the male uterus in the Hare and Rabbit, and says, " But the most extraordinary circumstance about the utriculus in these animals is this, that it receives the ejaculatory ducts. In all other instances, these open independently, by its sides, into the urogenital canal; but here, departing from this rule, they open into the undermost part of the Weberian organ," &c. It will thus be observed, from what we have above stated, that not only the Hare and Rabbit, but also the Elk, form exceptions to the general rule respecting the relation between the seminal ducts and the male uterus; and this is

* 'Cyclopædia of Anatomy,' art. Vesicula prostatica.

the more remarkable, inasmuch as in other species of Cervidæ the arrangement conforms to the general rule above stated. On either side of the veru montanum are two depressions which appear to be the openings of ducts. The absence of any glandular bodies appertaining to these, however, proved them to be merely superficial depressions of the mucous lining of the urethra.

Cowper's Glands (Pl. VII. fig. 6).—These are two in number, and are situated just behind the bulb of the urethra, being covered in part by the muscular fibres of that canal. Each is about the size of a garden-bean, and gives off a duct which opens into the bulbous portion of the urethra.

Penis measures 11 inches in length, and is laterally compressed. It consists of two corpora cavernosa and a corpus spongiosum. The latter presents a well-marked bulb posteriorly, whilst anteriorly it forms the glans (Pl. VII. fig. 8). This body is conical in form, flattened from side to side, and on its under surface is a shallow groove in which is placed the urethral orifice. There is no vermiform terminal portion of the urethra, such as occurs in many Ruminants. The muscles of the penis comprise an erector, which is arranged in the usual manner, and two retractores penis, the origins of which had been unfortunately divided, so that they could not be identified. The muscles themselves form two rounded and slightly flattened bands which pass forward, one on either side of the penis, to be inserted by means of an aponeurosis into the dorsal aspect of that organ at the junction of its anterior and middle thirds. In the flaccid condition the glans is entirely retracted within the prepuce. The latter is provided with four muscles—two protractors and two retractors. The protractors arise one on either side of the middle line from the abdominal aponeurosis midway between the xyphoid cartilage and the penis, and are inserted into the prepuce. The retractors arise, one on each side, from the abdominal aponeurosis in the inguinal region; their fibres pass transversely inwards, and are inserted along with the protractors into the prepuce. The scrotum is non-pendulous, and between it and the prepuce on either side of the middle line are two rudimentary teats. The anterior of these is situated at a distance of $3\frac{1}{2}$ and the posterior $2\frac{1}{2}$ inches from the middle line of the abdomen.

Myology.

For reasons afterwards mentioned, in treating of the muscular system, a comparison with that of other Ruminants has not been entered into in detail, but a simple description of the muscles of the body and limbs has been given. We have, for the sake of convenience, adopted the nomenclature of Chauveau*, but we do not consider ourselves bound by it in respect of general homological significance.

Muscles of the Fore Limb: Dorso-scapular Region.

Levator humeri (*Mastoido-humeralis*).—This muscle is attached posteriorly to the middle half of the anterior border of the shaft of the humerus. It is a strong muscular band which passes forwards and upwards along the side of the neck to be attached by means of a strong aponeurosis to the skull behind the ear. The lowest fibres of the muscle, moreover, pass over the angle of the jaw and parotid gland, and are prolonged forward as a cutaneous muscle of the cheek.

Great Dorsal Muscle (*Dorso-humeralis*).—The fibres of this muscle take origin from the spinous processes of all the dorsal vertebræ posterior to the highest point of the shoulder-blade, from a strong aponeurosis covering the external oblique muscle of the abdomen, and by a single digitation from the outer surface of the fourth last rib. The fibres pass obliquely downwards and forwards to be inserted as follows:—The anterior fibres terminate by blending with those of the posterior part of the teres major, whilst the posterior and lower fibres end on a cord-like tendon which passes in front of the teres major, and runs up to be inserted into the lesser tuberosity of the humerus, receiving the fibres of the lower half of the deep pectoral muscle, and giving off a tendinous slip which joins the brachial aponeurosis upon the inner side of the arm.

Trapezius.—This muscle arises by two distinct rounded tendons from the transverse process of the atlas, from the ligamentum nuchæ, and from the spines of all the dorsal vertebræ, with the exception of the last four, blending posteriorly with the origin of the great dorsal muscle. The fibres constituting the anterior and posterior thirds of the muscle are inserted into a strong aponeurosis covering the spinati muscles, and continuous with that covering the outer side of the arm. The central fibres of the muscle are inserted directly into the middle third of the spine of the scapula.

Rhomboideus arises from the third, fourth, fifth, sixth, and seventh dorsal spines, and from the ligamentum nuchæ between these; the fibres pass backwards and outwards, and are inserted into the whole length of the superior margin of the scapula.

* 'Traité d'Anatomie comparée des Animaux Domestiques.' The Second Edition, revised by S. Arloing and translated into English by George Fleming.

Angularis scapulæ arises in the middle of the cervical region from about 4 inches of the ligamentum nuchæ, passes downwards and backwards, and is inserted into the cervical angle of the scapula, where it coalesces with the anterior fibres of the serratus magnus.

Pectoral Region.

The superficial Pectoral Muscle arises from the anterior extremity of the sternum, and from the anterior two thirds of the inferior surface of that bone. The fibres are continuous with those of the opposite muscle, and pass outwards and backwards to terminate upon an aponeurosis which covers the anterior surface of the elbow-joint, and is continuous with the fascia of the forearm. This corresponds to that part of the muscle which is described by veterinarians as the sterno-aponeuroticus, whilst that portion of the muscle described by them as the sterno-humeralis has no representative in the Elk.

Deep Pectoral Muscle.—This is a large muscular mass, trapezoid in shape, and exceeding in size the superficial pectoral. It arises from the posterior three fourths of the inferior surface of the sternum, as well as from the aponeurosis which covers the rectus abdominis. The fibres pass forwards and outwards, and are inserted as follows:—The anterior half is attached to the lower border of the greater tuberosity of the humerus, to the lesser tuberosity of that bone, and between these to a strong fibrous band which arches over the biceps muscle; the posterior half of the muscular fibres is inserted along with the tendon of the great dorsal muscle.

Costal Region.

Great Serratus consists of a costal and a cervical portion. The costal portion arises by fleshy digitations from the eight upper ribs close to their junction with the cartilages, whilst the cervical part arises from the lower surfaces of the last three cervical vertebræ. The whole of the fibres converging form a fan-shaped muscle, which is inserted into the ventral surface of the scapula by two processes, one of which is attached to the anterior and the other to the posterior angle of that bone, these two insertions being united by a tendinous arch which bridges over the origin of the subscapularis.

Muscles of Shoulder.

Long Abductor of Arm (*Scapular Portion of the Deltoid*) is relatively a small muscle. It arises from the inferior extremity of the spine of the scapula, as well as from the fascia covering the subspinatus. The fibres so derived form a single muscle of a quadrilateral form, which is inserted into the outer bicipital ridge of the humerus and into the bicipital groove. It is to be observed that this muscle is not divided into two parts as in the horse.

Teres major (*Adductor of the Arm*) arises from the upper fourth of the

posterior costa of the scapula, and also from its posterior angle. It passes downwards and forwards, and is inserted by a ribbon-like tendon into the inner surface of the shaft of the humerus, about 2 inches below the head. Posteriorly this muscle receives the anterior fibres of the great dorsal muscle.

Teres minor (*Short Abductor of the Arm*) arises from the middle half of the posterior border of the scapula. The fibres run downwards and forwards, parallel to the subspinatus, and terminate by being inserted into the fascial origin of the external head of the triceps.

Superspinatus (*Antea spinatus*) arises from the supra-spinous fossa of the scapula and from the fascia covering it, and is inserted into the upper border of the great tuberosity of the humerus, as well as into its lesser tuberosity. Between these bony attachments the fibres are inserted in a similar manner to those of the deep pectoral muscle, by means of a strong fibrous band which arches over the long head of the biceps.

Subspinatus arises from the surface of the subspinous fossa and from the fascia which covers the muscle. The fibres end in a stout tendon which is attached to the outer surface of the great tuberosity of the humerus.

Subscapularis arises from the ventral surface of the scapula, with the exception of that portion which receives the insertion of the great serratus; its fibres pass downwards to be inserted by means of a strong tendon into the inner surface of the lesser tuberosity of the humerus. At its origin this muscle is partially divided into three portions, the central one being bridged over by the tendinous arch of the great serratus.

Anterior Humeral Region.

Coraco-humeralis arises along with the biceps from the coracoid process of the scapula, and is attached by means of a linear insertion into the whole length of the inner surface of the shaft of the humerus.

Long Flexor of Forearm (*Biceps*) is a single-headed muscle which arises by means of a thick flattened tendon from the coracoid process of the scapula. This tendon, passing over a trochlear surface on the superior extremity of the humerus, gives place to a fleshy belly which terminates in a strong flattened tendon. This tendon divides into two parts, of which the outer is inserted into the inner border of the radius close to its head, whilst the inner, passing off at right angles, is inserted into the inner border of the olecranon process of the ulna.

Short Flexor of Forearm arises from the posterior surface of the shaft of the humerus immediately below the head, as well as from the outer surface of the root of the great tuberosity. The muscle winds spirally round the external surface of the humerus, and is inserted by a flattened tendon into the inner border of the shaft of the ulna just below the olecranon process.

Posterior Humeral Region.

Triceps Extensor Brachii.—This muscle possesses four distinct heads, which arise as follows:—The outer head has an almost horizontal origin extending from the lower border of the articular surface of the head of the humerus, as far forwards as the outer surface of the base of the great tuberosity. This head receives the fibres of insertion of the teres minor. The middle head is the largest, and arises from the posterior margin of the scapula for about two thirds of its length. A third head is attached to the posterior surface of the shaft of the humerus immediately above the olecranon fossa, whilst the fourth head has an oblique linear origin from the inner side of the upper half of the shaft of the humerus. The fibres derived from these different sources terminate on a single stout tendon which is inserted into the olecranon process of the ulna, after giving an offshoot to the fascia on the back of the forearm. The third head described above corresponds to the anconeus (*Epicondylo-olecranius*).

Muscles of the Forearm: Anterior Radio-ulnar Region: Extensors.

Anterior Extensor of Metacarpus is a broad fleshy muscle which arises from the whole length of the external condyloid ridge of the humerus, and also from the anterior part of the capsular ligament of the elbow-joint. It is inserted by a stout tendon into the anterior border of the head of the great metacarpal bone.

Oblique Extensor of Metacarpus arises from the middle third of the external surface of the radius. The muscle crosses from without inwards, and ends on a tendon which, passing underneath the extensor of the phalanges and superficial to the anterior extensor of the metacarpus, is inserted into the inner small metacarpal bone.

Anterior Extensor of Phalanges consists of two distinct portions. The inner arises along with that portion of the anterior extensor of the metacarpus which is attached to the capsular ligament of the elbow-joint, and forms a fusiform belly which terminates on a tendon opposite the lower end of the radius. This tendon forms an expansion in front of the metacarpo-phalangeal articulation, from which three bands pass to be inserted into the inner, outer, and dorsal surfaces of the second phalanx of the inner of the two anterior toes. The outer portion of the muscle arises from the outer side of the external condyle of the humerus, by fleshy fibres from the posterior aspect of the upper extremity of the radius, and from an aponeurosis attached to the lower half of the posterior border of the ulna. From this head a tendon is given off, which is distributed to the outer of the two anterior digits, its insertion resembling that of the tendon of the same muscle to the inner toe; but in addition it also gives off, about the middle of the metacarpus, a lateral slip which passes to the terminal phalanx of the outer of the two posterior toes.

Long Extensor of the Phalanges.—This arises by two heads, one of

which is attached to the outer side of the external condyle of the humerus, and the other to the outer surface of the radius 3 inches below the olecranon. The first head ends on two tendons, of which the stronger passes downwards in front of the metacarpo-phalangeal articulation, lying between the two tendons of the preceding muscle, below the expansion of which it divides into two slips, each of which is inserted into the terminal phalanx of an anterior toe. The other and smaller tendon passes down to be inserted into the last phalanx of the inner of the two posterior toes. The second head terminates in a tendon which unites with that of the long extensor opposite the wrist-joint.

Note.—The anterior and long extensors have been thus described for the sake of clearness. With reference to their action, they may be regarded as different parts of the *extensor pedis* of veterinarians.

Posterior Radio-ulnar Region: Flexors.

External Flexor of Metacarpus arises by means of a stout tendon from the posterior border of the external condyle of the humerus. It passes along the outer and posterior aspect of the forearm, and is inserted by means of a tendon common to it and to the following muscle into the pisiform bone, as well as into the proximal extremity of the great metacarpal bone.

Oblique Flexor of Metacarpus.—This muscle originates by two heads, one from the inner side of the olecranon, and the second from a depression on the inner side of the internal condyle of the humerus. These two heads unite upon a tendon which blends with that of the preceding muscle and is inserted along with it.

Internal Flexor of Metacarpus (*Palmaris magnus*) arises from the inner condyle of the humerus, below the origin of the oblique flexor, and terminates on a rounded tendon, which is inserted into the inner and posterior border of the proximal end of the great metacarpal bone.

Flexor sublimis Digitorum arises together with one of the heads of origin of the flexor profundus from the posterior border of the inner condyle of the humerus. The muscular fibres terminate at the lower end of the forearm in two tendons which pass along the whole length of the metacarpal bone, and are perforated opposite the metacarpo-phalangeal articulations for the transmission of the corresponding deep flexor tendons. Each is inserted by means of two slips into the base and sides of the second phalanx of each of the two anterior toes. Behind the wrist-joint this muscle is connected by means of two tendinous slips to the tendon of the deep flexor on its inner side and to the pisiform bone on its outer side.

Flexor profundus Digitorum arises by two heads, an inner and an outer. The inner head is the stronger, and arises in common with the flexor sublimis, whilst the outer head is attached to the inner side of the olecranon process. The inner head of the muscle, moreover, is more or less divisible into two parts. These end behind the wrist on a single

tendon, which is joined by the long slender tendon of the outer head. The single tendon thus formed passes down as far as the metacarpo-phalangeal articulation, where it divides into two parts, each of which, after perforating the corresponding tendon of the flexor sublimis, is prolonged to the terminal phalanx of an anterior toe.

Muscles of the Hind Limb: Gluteal Region.

Long Vastus is a large muscular mass which arises from the middle line of the sacrum posteriorly, from the upper border of the ischium, and by a strong tendon from the tuberosity immediately below that border. The fibres pass outwards and downwards, the anterior ending on a special tendon which is inserted into the outer border of the patella, blending with the insertion of the extensor mass, whilst the remaining fibres end on a strong aponeurosis which covers the upper half of the external muscles of the leg.

Superficial Gluteus arises from the outer surface of the iliac bone, reaching as far back as the sciatic foramen, from a strong aponeurosis covering the muscle, and from the fascia lumborum; the fibres pass almost directly backwards and converge to be inserted into the upper and posterior borders, as well as into the outer surface of the great trochanter of the femur.

Deep Gluteus.—This muscle lies under cover of the preceding, and is bilaminar, the two laminæ being united along their inferior borders, but separated posteriorly where the sciatic nerve passes between them. The superficial part arises from the external surface of the iliac bone, the deeper portion from the outer surface of the ilium in front of the sciatic notch, from a fibrous membrane which covers the notch, and also from the great sciatic ligament. The fibres from both laminæ converge, and are inserted into the anterior surface of the great trochanter, as well as into the adjacent part of the shaft of the femur.

It will be observed that we have only described two glutei muscles. The bilaminar character of the deeper of these indicates its probable homology with the two deeper glutei muscles usually described in the horse; or it may be that they correspond only to the deepest gluteus, which in the Ruminants is described by Chauveau as being divided into two portions, each of which is referred to by Rigot as a distinct and separate muscle.

Obturator Internus arises from the whole of the ischio-pubic portion of the pelvic wall and from the inner surface of the obturator membrane. The fibres pass obliquely forwards and upwards, and the tendon of the muscle escaping from the pelvis through the small sciatic notch, is joined by the fibres of the gemellus, and is ultimately inserted into a deep pit on the inner side of the great trochanter of the femur.

Gemelli.—These muscles are conjoined, and form a single concave muscular mass, in the concavity of which the extra-pelvic portion of the obturator internus muscle lies. The muscle takes its origin from the border of

the small sciatic notch, and joining the obturator internus tendon is inserted along with it.

Square Crural Muscle (*Quadratus Femoris*) is attached internally to the inferior border of the ischium, under cover of the posterior fibres of the long vastus; the fibres form a flattened band which passes transversely outwards to be attached externally to a bony ridge on the shaft of the femur, which is continuous with the posterior border of the great trochanter.

Obturator Externus arises from the pubic bone external to the origins of the adductor longus and pectineus, from the ischium behind the obturator foramen, and from the outer surface of the obturator membrane; the tendon of this muscle coalesces with that of the obturator internus, and is inserted along with it.

Pelvi-femoral Region.

Psoas Magnus arises from the transverse processes and bodies of all the lumbar as well as of the last two or three dorsal vertebræ, and before passing out of the cavity of the pelvis unites with the iliacus, with which its insertion is described.

Iliacus arises from the external border of the ilium, as far back as the acetabulum, and from nearly the whole of the iliac fossa. Its tendon unites with that of the foregoing muscle, and the two are inserted together into the small trochanter, and about an inch of the shaft of the femur below that process.

Psoas Parvus.—About half the size of the psoas magnus, lies internal to that muscle, and arises from the bodies of the same vertebræ which afford attachment to the latter. Its tendon is inserted into the ilio-pectineal eminence, as well as to the adjoining portion of the ilio-pectineal line.

Anterior Femoral Region.

The Muscle of the Fascia Lata (*Tensor Vaginæ*) arises as a fleshy bundle from the anterior extremity of the crest of the ilium, from about two inches of the surface of the bone immediately behind the crest, and also from the fascia covering the superficial gluteus; the posterior fibres of the muscle end in the fascia covering the outer side of the thigh, whilst the anterior (which form the larger part of the muscle) run downwards to join the extensor tendon of the knee.

Long Adductor of the Leg (*Sartorius*) arises fleshy from the anterior inferior spine of the ilium, by a tendon from the ilio-pectineal line, and from the iliac fascia. The fibres form a ribbon-like muscle which lies in the interval between the other adductors and the extensors. It is inserted into the inner border of the ligamentum patellæ and into the inner side of the upper end of the tibia. Its insertion is united with the upper border of the tendon of insertion of the gracilis.

Vastus Externus.—This muscle arises from the anterior margin of the great trochanter, from the upper half of the linea aspera, and from the

upper three fourths of the external surface of the shaft of the femur. The muscle is inserted along with the rectus femoris.

Vastus Internus takes its origin from the anterior intertrochanteric line, from the upper half of the internal surface of the shaft of the femur, and from the upper three fourths of the anterior surface of that bone. The fibres blend with those of the preceding muscle, and are inserted along with those of the next muscle.

Rectus Femoris arises from the inferior border of the iliac bone immediately in front of the acetabulum. Its fleshy fibres pass downwards, and terminate in a tendon common to it and the two preceding muscles. This tendon is inserted into the anterior tubercle of the tibia, it receives on its outer side some of the fibres of the long vastus, and on its inner those of the long adductor of the leg.

Internal Femoral Region.

Short Adductor of the Leg (*Gracilis*).—Has an extensive origin from the lower surface of the pubic bone close to the symphysis, and from a median tendinous band which separates it from the opposite muscle. This band extends back as far as the anus. The muscle is inserted by means of a broad aponeurotic tendon, the upper half of which is attached to the inner border of the tibia, whilst the lower half unites with the fascia covering the inner head of the gastrocnemius.

Pectineus arises from the inferior border of the pubis close to the gracilis. It passes downwards, and winds round the middle of the femur to be inserted into the posterior border of the shaft of that bone.

Adductor Femoris arises from the outer surface of the body of the pubis, between the origins of the pectineus and semi-membranosus, and is inserted into the posterior border of the femur, its insertion corresponding to that of the pectineus, but extending a little further down.

Posterior Femoral Region.

Semi-membranosus arises from the external surface of the pubic arch, its origin extending from the posterior extremity of the symphysis to the tuberosity of the ischium. Its insertion is into the lower third of the internal condyloid line of the femur, into the internal lateral ligament of the knee-joint, and into the internal tuberosity of the tibia.

Semitendinosus.—This muscle arises, together with the vastus longus, from a special tubercle of the ischium below the tuberosity of that bone, as well as from the tuberosity itself, and from the upper border of the ischium. The fibres form a thick fleshy mass, which lies parallel to the posterior border of the vastus longus, and is inserted beneath the gracilis into the inner border of the upper part of the shaft of the tibia, and also into the fascia covering the gastrocnemius.

Muscles of the Leg: Posterior Tibial Region.

Gastrocnemius arises by two heads, one from the outer, and the other from the inner condyloid ridge of the femur. The heads unite together about the lower third of the tibia, and are inserted by means of a stout tendon which splits into two parts, a superficial and a deep. The superficial extends as far as the lower end of the metatarsal bone, where it divides into two slips which are inserted into the bases of the second phalanges of the anterior toes. Between these slips the tendon of the flexor perforans passes forward to the toes. The deeper portion of the tendon is inserted into the tuberosity of the os calcis.

This description includes under one head both the flexor perforatus and gastrocnemius, these two muscles being inseparably united. With reference to the muscles of this region we have departed slightly from the nomenclature of Chauveau, our plantaris forming a portion of his flexor perforatus.

Soleus is fusiform and arises along with the outer head of the gastrocnemius. It terminates by joining the tendon of this latter muscle.

Plantaris is a delicate muscle which arises from the external condyloid ridge of the femur, and from the posterior part of the capsule of the knee-joint. It terminates by blending with the outer head of the gastrocnemius.

Popliteus arises by a strong tendon from a pit on the outer side of the external condyle of the femur. Its fleshy belly is inserted into the upper third of the posterior surface of the tibia.

Flexor perforans digitorum.—Arises by three heads. The superficial head is attached to the posterior border of the external tuberosity of the tibia. The two deeper heads arise, one from the posterior surface of the upper two thirds of the tibia with the exception of so much of the bone as affords insertion to the popliteus, and from an intermuscular septum attached to the external border of that bone; whilst the other springs from the internal and lower half of the oblique line of the tibia, and separates the second head of origin of this muscle from the popliteus. The tendons derived from the first and second heads unite opposite the lower end of the tibia and are joined below the ankle-joint by that of the third head. The common tendon thus formed passes as far as the lower end of the metatarsal bone, where it divides into two slips, one of which is inserted into the base of the last phalanx of each of the anterior toes, after passing between the tendinous slips supplied to the same toes by that part of the gastrocnemius which corresponds to the flexor perforatus. The third head of origin of the flexor perforans corresponds to the oblique flexor of the phalanges of Chauveau.

Interossei.—These are represented almost entirely by ligament corresponding to the suspensory ligament of the fetlock in the horse. It consists of a stout musculo-tendinous band, which extends along the whole length of the metatarsus. The muscular portion does not appear to be arranged in any definite manner. Above the metatarso-phalangeal articu-

lation the band divides into three portions, a central and two lateral; the central portion after being connected to the sesamoid bones in this region is inserted into the bases of the first phalanges of the two anterior toes; the lateral portions pass one along the outer, and the other along the inner side of the metatarso-phalangeal joints to terminate on the dorsal aspect of the second phalanges of the anterior toes, by uniting with the extensor tendons.

Anterior Tibial Region.

Flexor of the Metatarsus arises by two heads. One is attached by means of a strong tendon to a pit on the front of the external condyle of the femur, as well as by muscular fibres to the outer surface of the anterior tibial spine. The fibres give place to a stout tendon which passes beneath an annular ligament situated just above the ankle-joint, and is inserted into the inner side of the upper end of the great metatarsal bone, after being perforated by the tendon of insertion of the second head of the muscle. This second head is attached superiorly to the outer side of the anterior tibial spine, to the outer side of the shaft of the tibia, and to a stout fascia which conceals the tendon of the first head. The tendon of the second head passes beneath the annular ligament, perforates that of the first head, and is inserted immediately below it.

Peroneus (*lateral flexor of phalanges*) arises from the external tuberosity of the tibia behind the extensor of the toes, and from a strong intermuscular septum which separates it from the neighbouring muscles opposite the upper two thirds of the tibia. Its tendon of insertion passes along the outer side of the ankle and beneath the inferior annular ligament to the lower end of the metatarsal bone, where it forms a flattened expansion, which is inserted into the dorsal aspects of the second phalanges of the anterior toes.

Extensor of the Phalanges arises by means of two muscular bellies from the outer condyle of the femur; these end on separate tendons which pass together beneath both anterior annular ligaments as far as the lower end of the metatarsal bone. The inner tendon unites with the fibrous expansion formed by that of the peroneus, whilst the outer divides opposite the metatarso-phalangeal articulation into two slips, which pass to be inserted into the terminal phalanges of the anterior toes. This latter tendon is moreover joined about the middle of the metatarsal bone by a small fleshy slip which arises from the proximal end of that bone.

A muscle, which appears to have no representative in the horse, and which forms as it were a second flexor of the metatarsus, arises from the outer surface of the external tuberosity of the tibia and from the fascial septum between it and the peroneus. It ends on a delicate tendon which is inserted into a deep pit on the posterior and external aspect of the metatarsal bone about one inch below its upper end.

Body and Abdominal Muscles.

Panniculus Carnosus is strong and arises from an aponeurosis covering the buttock, from the region of the knee-joint, and from an aponeurosis which covers the dorsal region ; the fibres pass obliquely forward and downward, the posterior ending in the abdominal aponeurosis, whilst the anterior fibres converge and end on the fascia covering the axilla.

External Oblique arises by seven digitations from the outer surfaces of as many of the lower ribs ; it is inserted in the usual manner upon the abdominal aponeurosis.

Internal Oblique arises from the outer half of Poupart's ligament, and from the anterior half of the crest of the ilium. Those fibres of the muscle which arise from the ilium are inserted into the last rib, whilst the remainder of the muscle terminates upon the abdominal aponeurosis.

Transversalis.—This muscle arises through the medium of the lumbar aponeurosis from the transverse processes of the lumbar vertebræ, as well as from the posterior margin of the thorax as far forward as the tip of the cartilage of the fourth last rib. It is inserted into the abdominal aponeurosis.

Rectus Abdominis has a tendinous origin from the median raphé which separates the adductor muscles of the thighs. The muscle is inserted into the cartilages of the posterior ribs.

Concluding Remarks.

Having now completed the account of our observations, it may be as well that we should add a few words by way of comparison of the anatomy of the Elk with that of other Ruminants. In respect of the large size and compound nature of the buccal papillæ, this animal differs from most of the Cervidæ in which they are simple and conical in form, and agrees rather with the Camel and Giraffe. The tongue, viewed either with reference to its form or the arrangement of its papillæ, does not deviate essentially from the Cervine type. Professor Garrod* says with regard to the stomach of Ruminants :—"The rumen varies as to the shape and distribution of the villi on its mucous membrane. In most of the smaller species the folds which constrict the viscus, as well as the pouches between them, are covered internally with villi, though these are larger in the latter situations. In most of the larger species the villi are absent on the folds, and are largest in the middle of the pouches." *Alces* therefore agrees with the smaller species of Ruminants, and not with the larger, as regards the distribution of the villi, whilst their spatulate form recalls to mind the exceptional appearance of these structures in the Rein-

* Proceed. Zool. Soc. 1877, p. 3.

deer* rather than the cylindrical form which they present in the majority of the Cervidæ. Shallowness of its cells characterizes for the most part the Cervine reticulum; and in respect of this division of the stomach, the Elk agrees with the majority of Deer, including the Reindeer, in which, according to Professor Owen †, the cells are extremely shallow. The laminæ of the psalterium in the majority of Deer are, according to Prof. Garrod, quadruplicate, and to this general observation the Elk forms no exception; at the same time it is to be observed that in this animal the smallest laminæ are represented by rows of papillæ, an arrangement which, according to the tables of the author just named, is also met with in certain species of the genus *Cervus*, but which is by no means so common as that in which the papillæ have completely coalesced to form continuous laminæ. The greatest divergence from the Cervine type, so far as the alimentary canal of the Elk is concerned, is to be found in the comparative lengths of the small and large intestines. According to Meckel ‡ the small intestine in the Cervidæ as a rule measures more than twice the length of the large, an observation which is substantiated by a reference to the tables of Prof. Garrod §, whereas in the Elk the large and small intestines are of nearly equal lengths. In this respect the Elk agrees more closely with the Camelidæ, in which, according to Meckel, the small and large intestines are of equal length, than with other members of the genus *Cervus*, only one species of which (*Cervus elaphus*) at all approaches these measurements, and in it the length of the small intestine exceeds that of the large by one third.

With regard to the comparative lengths of the cæcum and large intestine, as well as the absence of a gall-bladder, *Alces* agrees with the Cervidæ in general.

Passing now to the generative organs, we find that Leuckart ‖ figures in the Stag vesiculæ seminales which are almost the counterpart of those we found in the Elk; and the resemblance between the genitals of the two animals is further borne out by the absence of a prostate gland in both. According to Pittard ¶ and Murie**, it is possible that these vesiculæ may represent the pros-

* Owen's 'Anat. of Vertebrates,' p. 471.

† *Ibid.* p. 472.

‡ Cyclopædia of Anatomy, Cobbold, art. Ruminantia.

§ *Loc. cit.* p. 5.

‖ Cyclopædia of Anatomy, art. Vesicula prostatica.

¶ Cyclopædia of Anatomy, art. Vesicula seminales.

** Proceed. Zool. Soc. 1870, p. 352.

A.H Young del

Fig 1

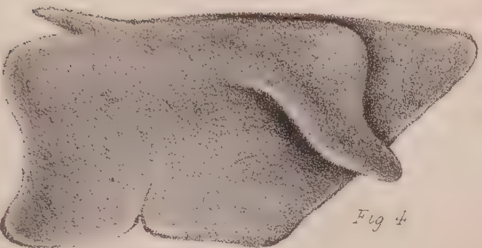


Fig 4

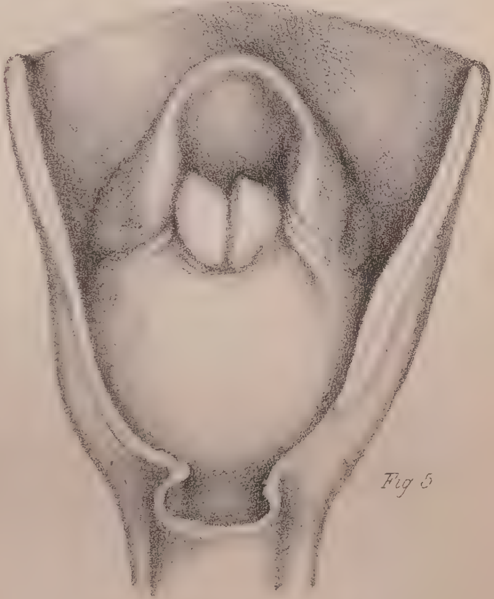


Fig 5

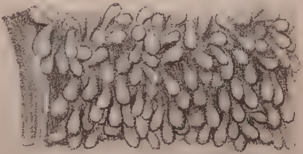


Fig. 3.

Fig. 2.

erjeau lith. LARYNX & DIGESTIVE ORGANS OF ELK. Fitch imp

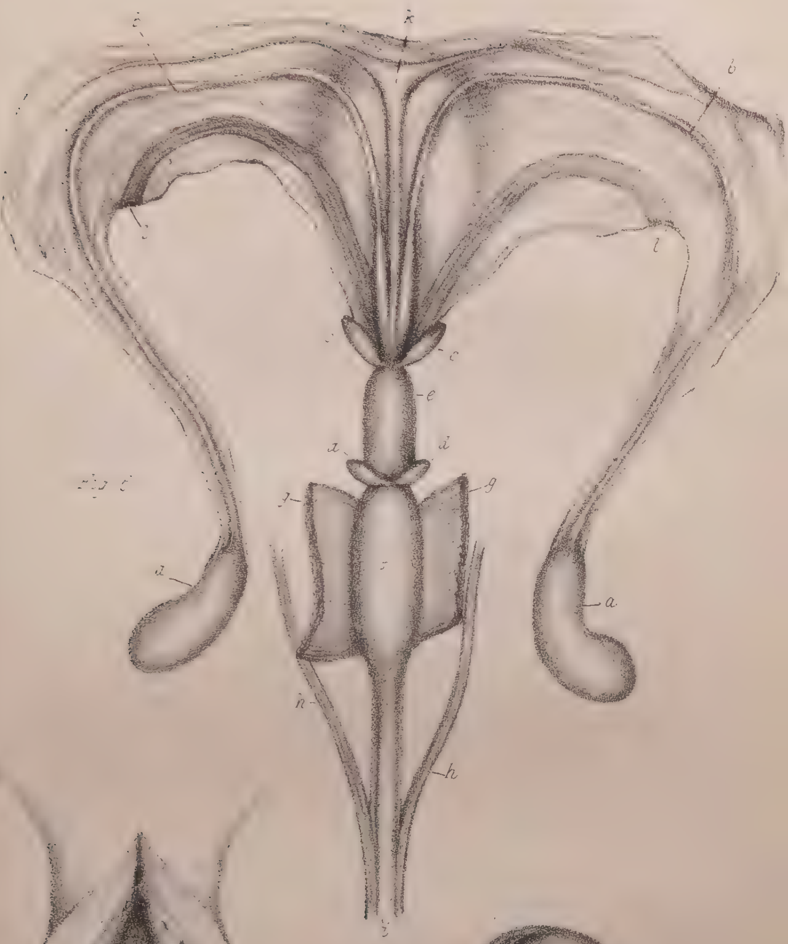


Fig. 7

Fig. 8.

GENITALIA OF ELK.

tate as well; but this view appears to us to be untenable, inasmuch as the vesiculæ of these deer are true diverticula of the vasa deferentia, and that each opens into the urethra along with the vas deferens of the same side. Cowper's glands are present in several species of *Cervus*, whilst in others they are absent. Their presence would appear to be of no great importance in determining the classification of this group. They are absent in *Cervus elaphus*, which in some respects approaches closely to the Elk, in which they are present. The large size and peculiar form of the vesicula prostatica above described differs much from the rudimentary organ figured by Leuckart * in the Stag, but closely resembles the corresponding organ in the Goat. Unfortunately the very limited number of observations on its configuration in different species of Deer prevents any general conclusion being drawn regarding its arrangement in this group. The glans penis, to the form of which as an element of classification of the Ruminants Prof. Garrod † attributes some weight, in the Elk resembles more closely that of *Cervus cashmerianus* than that of any other species figured by the author just named.

Comparative deductions respecting the myology of the Elk do not seem advisable until it be completely worked out. So far as the muscles of the limbs are concerned, they are seen to closely resemble those of the Ox and Sheep amongst Ruminants. Owing to the want of definite information on the myology of Cervidæ, it is impossible to arrive at any conclusions regarding the comparison of the Elk in this respect with the animals to which it is most closely allied.

Taking into consideration, however, those anatomical features of the Elk which are brought out in the foregoing description, there can be no doubt but that they lead to the conclusion that in all essentials the animal is a true though somewhat aberrant species of Deer; at the same time it appears doubtful if the deviation from what may be called the normal Cervine type is sufficient to justify the creation of a separate genus for the reception of *Cervus alces*.

DESCRIPTION OF THE PLATES.

Plate VI.

Fig. 1. Dorsum of tongue showing papillæ (half natural size).
2. Mucous membrane of the cheek with papillæ (natural size).

* Cyclopædia of Anatomy, art. Vesicula prostatica.
† Proceed. Zool. Soc. 1877.

Fig. 3. Papillæ of the mucous membrane of rumen (natural size).
4. Outline of liver (reduced).
5. Larynx from behind.

PLATE VII.

Fig. 6. Male generative organs. The outline of the bladder is seen through the peritoneum. The lettering applies as follows:—*a a*, testicles; *b b*, vasa deferentia; *c c*, vesiculæ seminales; *d d*, Cowper's glands; *e*, intrapelvic portion of urethra; *f*, bulb of urethra; *g g*, erectores penis; *h h*, retractores penis; *i*, penis; *k*, vesicula prostatica; *l l*, ureters.
7. Intrapelvic portion of the urethra laid open, showing the single opening common to the two seminal ducts: *a*, muscular fibres; *b*, erectile tissue.
8. Glans penis.

On the Geographical Distribution of the Gulls and Terns (*Laridæ*). By HOWARD SAUNDERS, F.L.S., F.Z.S.

[Read April 18, 1878.]

To those who have only a general knowledge of the family of the Laridæ, which comprises the subfamilies *Sterninæ* (Terns), *Rhynchopsinæ* (Skimmers), *Larinæ* (Gulls), and *Stercorariinæ* (Parasitic Gulls), it may seem that there is but little to be said respecting the geographical distribution of a group whose conditions of existence being almost entirely dependent upon water, and, in the majority, marine, are therefore particularly favourable to dispersion and general distribution, and opposed to the development of specialized forms. A closer investigation of the subject shows, however, that whereas some members of the family have an exceedingly wide range, there are, on the other hand, many remarkable and isolated forms which, for reasons as yet unknown to us, are restricted to very narrow geographical areas. In some instances it is not difficult to trace the connexion with the other members of the same group; and in other cases the existing gaps between closely allied species may be explained, with a fair show of probability, by the alterations which are known to have taken place in the geographical features of the area now inhabited. But even then it must often be a matter for wonder that birds of such powers of flight should consent (if I may use the word) to remain within such confined limits, when the causes which formerly might have proved a barrier to their extension have for ages disappeared.

There are, however, several remarkable instances of this apparently voluntary restriction which are not to be accounted for by deficiency or variation in food, nor even by climatic changes. These cases are more frequently to be found amongst the Gulls (*Larinæ*), which, being to a great extent omnivorous, are the scavengers of the shores; whilst the Terns (*Sterninæ*) obtain their sustenance almost entirely from the sea or from inland waters, and are also, by their slender shape and length of wing, obviously adapted for long and sustained flights. Yet even amongst the Terns there are several remarkable cases of isolation and restriction; and it is in this group that we are more especially enabled to trace several interesting links in the chain of dispersion accompanied by gradual variation.

It is not necessary to occupy more space with preliminary remarks; but I my observe that my investigations during the past seven years lead me to accept about 53 recognizable species of Terns and Skimmers, 50 of Gulls, and 6 of Skua Gulls, a considerable reduction from the 160 species upheld by Bonaparte in his latest revision of the Longipennes. Even of the accepted species, there are, however, several which are little more than climatic varieties, and they will merely be alluded to in the course of my remarks upon the general distribution of the groups of which they form part. Nor is it my intention to lay any stress upon solitary and accidental stragglers to places far removed from their normal habitat, especially where these apparitions are those of immature birds, which generally wander far more than adults—my object being to bring forward the broad features of the geographical distribution of the members of this family, without dwelling upon trifling and irrelevant exceptions.

For convenience of treatment it will be better to commence with the *Stercorariinæ*, or Skua Gulls (*Lestridinæ*, Illiger), which inhabit the Arctic and Antarctic seas. Two out of the four northern species are very closely allied. The most Arctic in its habitat, *Stercorarius parasiticus* (L.), commonly known as Buffon's Skua, being an elegant long-tailed form of the stouter and shorter-tailed species *S. crepidatus* (Gm.), which, to avoid mistakes, I call Richardson's Skua, a vernacular name originally applied to a melanic variety of the species, but adopted as the least liable to cause confusion. The former breeds throughout the regions to the north of the Arctic circle, straying southward in winter, both in the Atlantic and Pacific. Its extreme range on

record being that of a young bird obtained between the Philippines and the Sandwich Islands, to which Bonaparte gave the name of *Lestris hardyi*; this example is in the Berlin Museum, where I have recently examined it. Richardson's Skua has a more southern breeding-range, nesting as far down as the Orkney and Shetland Islands, whence it goes in winter as far as the Cape of Good Hope, and in all probability up the east coast of Africa to Persia and the coast of Scind, being apparently the species described from there by Mr. A. O. Hume as *S. asiaticus*. On the Atlantic side of America it goes to Rio Janeiro, being apparently the species described by Solander, in his unpublished MS. in the British Museum, under the names of *Larus fuliginosus* and *L. nigricans*; and it probably visits the Pacific coasts, as a solitary example which I refer to this species was obtained by Mr. Buller in the Province of Wellington, New Zealand. Both these species possess great powers of flight, so that they are able to pursue and rob, not only the smaller Gulls, but also the Terns; and as the latter are found in an uninterrupted succession throughout the whole of the indicated range, there is at once an assignable reason for great extension in the range of the latter of these two Skuas. A larger and stouter species, with broad-pointed central tail-feathers, *S. pomatorhinus*, with an Arctic breeding-range nearly identical with that of *S. parasiticus*, has nearly as extensive a southern range as *S. crepidatus*, immature birds having occurred in West Africa down to Walwich Bay, and once at Cape York, North Australia; whilst in the North Pacific it has occurred at the Prybilov Islands, and the 'Challenger' Expedition obtained a fine adult specimen in Inosima, Japan. In powers of flight this bird is nearly if not quite equal to its two congeners, and the same causes probably influence its distribution.

But now, on leaving these three perfectly distinct species, we come to three others whose distinctions are comparatively trifling, at the same time that the gradations of differences and geographical distribution are very interesting. The northern species, *S. catarrhactes*, whose breeding-range stretches from the coast of Norway, the Faroes, and Iceland, away through the Nearctic region and the Pacific, appears to be nowhere numerically abundant, and is fast becoming exterminated in Europe. It is a bold, predacious, but somewhat heavy bird, addicted at times to the slaughter of lambs, and deriving its main sustenance from plundering the Gulls, especially the Kittiwake (*Rissa tridactyla*), upon which, more-

over, it seems to prey; for Capt. H. W. Feilden found the bones and feathers of that species in the stomachs and castings of the Skuas at the Faroes. In winter it ranges down to the Straits of Gibraltar, and perhaps a little further; and on the Pacific side it has *once* been obtained, as recorded by Lawrence, at Monterey, California. It would probably have little chance of overtaking a Tern, but it is quite fast enough to tyrannize over any of the smaller Gulls; and it is interesting to observe that its range coincides with the winter range of the Kittiwake. As already shown, it has occurred in California; but descending that coast, we find no trace of a large Skua until we enter the fish-abounding, and therefore gull-frequented, waters of Humboldt's Current, which cools the coasts of Chili and Peru throughout a width of about 300 miles, and sweeps outwards to diminish the natural heat of the equatorial Galapagos Islands. In these productive waters is found a large Skua, *S. chilensis* (*vide* P. Z. S. 1876, p. 323, pl. xxiv.), separable from the northern *S. catarrhactes* by its brighter and more chestnut underparts and axillaries—differences which are constant, although it is true that they are merely those of colour. Its bill is perhaps a trifle more slender than that of the northern bird, a point which should be borne in mind, because on passing through the Straits of Magellan, where this species appears to stop, we come at once to another large Skua, *S. antarcticus*, which, although in such close geographical proximity to *S. chilensis*, yet differs far more from it than *S. chilensis* does from *S. catarrhactes*! The Antarctic Skua ranges from the Falkland Islands down to the edge of the pack-ice, the shores of New Zealand, and up to Norfolk Island, and thence by way of the chain of Kerguelen Island, St. Paul's Island, the Crozets, &c., it reaches the Cape of Good Hope and, as a straggler, Madagascar. From the Cape it works round by Tristan d'Acunha and the South Atlantic islands, till the chain is completed at the Falklands again. *S. antarcticus* is a uniformly dusky bird, with stronger and shorter bill than either of its near relatives; but it is interesting to observe certain slight variations in the chain even in the selfsame species. The largest birds are from the Southern Ocean, between New Zealand and the Cape of Good Hope, and they are also the duskiest in colour; those from the South Atlantic are smaller, and have a tendency to a pale frill of acuminate feathers, similar to that which is more or less marked in all the other Skuas; whilst the three individuals obtained by the 'Erebus' and 'Terror'

Expedition from the edge of the pack-ice, now in the British Museum, are wonderfully bleached and weird-looking birds. On reading the account given by Dr. Kidder respecting the habits of this species at Kerguelen Island, where it seems to avoid water and to prey principally upon the flesh of other birds, it is rather remarkable that it should have varied so little; but so far as our present defective knowledge of distribution goes, the evidence seems to point to the North Pacific as the district whence the members of this group originally sprung. I am quite prepared to learn that *S. chilensis* goes as far as the Galapagos, which would considerably narrow the gap which separates it from *S. catarrhactes*. *S. antarcticus* is a still more specialized offshoot, entirely absent from the great space which lies between New Zealand and the western shores of South America, and probably restricted from ascending the eastern coast of that continent and the coasts of Africa by the absence from those districts of the gulls upon which it can directly or indirectly prey.

In the North Pacific, again, where the Aleutian Islands form a broken chain between Alaska and Kamtschatka, and enclose Behring's Sea, is found a distinct and very local species of Kittiwake Gull (*Rissa brevirostris*, Brandt), having a short stout bill, rudimentary hind toe, a grey mantle much darker than in the Common Kittiwake, and orange legs and feet, but which calls for no further remark. Over the same area is found the Common Kittiwake, *Rissa tridactyla*, a species which ranges throughout the whole Arctic and Subarctic regions, descending on the Atlantic coasts somewhat further than on those of the Pacific. The vast majority of individuals throughout this area are precisely identical; but *some* of the *Alaskan* examples have a minute but distinctly formed hind toe, and even a nail, although this peculiarity is not always equally developed on both feet of the same bird! Inasmuch as every other member of the family of the Laridæ, except *Rissa*, has a fully developed hind toe, it is tolerably evident that in *Rissa* it has for some reason become obsolete; and as the survivors of the hind-toed *Rissæ* are only found round Alaska, it would appear probable that the North Pacific in this case also is the point of dispersion and variation for this genus.

Amongst the typical Gulls there are only two species, *Larus glaucus* and *L. leucopterus*, which have white primaries devoid of dark markings or "pattern"; and these two range throughout the whole Arctic and Subarctic region, including the North Pacific

from Alaska to Japan. It is, however, only in the North Pacific and North-western America that we find *L. glaucescens*, a gull of similar dimensions but with faintly barred primaries, which give it in effect the appearance of a washed-out Herring-gull (*L. argentatus*). It is a perfectly recognizable species, but it is clear that it forms a connecting-link between these two groups; and as it is well-established that the Herring-gulls which are resident furthest north are lighter in colour than southern examples, it is not difficult to trace out the gradual diminution of colour through *L. glaucescens*, till the total loss of it is reached in *L. glaucus* and *L. leucopterus*. In the Herring-gull group, again, all the forms—call them species or varieties—are found in the North Pacific. It is there that we meet with *L. argentatus* of our islands, Western Europe, and North America, as distinguished by its pale flesh-coloured legs and pale eyelid from *L. cachinnans*, with its slightly darker mantle, yellow legs, and bright brick-red eyelids, which takes the place of *L. argentatus* in the Mediterranean, over the steppes of Russia and Siberia, and coasts of Asia, and reaches to the Pacific seaboard of China. *L. affinis*, Reinhardt, with a yet darker mantle and wings, which, however, still show a distinct pattern in their outer primary feathers, is also to be found in the North Pacific. The explorations of Messrs. Seebohm and Harvie Brown on the Petschora have shown us that this last species merely visits Northern Europe and Siberia to breed at a time when there is an almost continuous sunshine, whilst the rest of the year is passed in the brilliant atmosphere of the Red Sea and the coasts from thence to India. Bearing in mind the gradual increase in intensity of colour in proportion to the amount of continued sunshine experienced by all these gulls, and the increasing pallor amongst the species which mainly inhabit the north, it seems impossible to avoid the deduction that many of these varieties which we agree to call species are almost entirely due to climatic influence. Of the three species named, two are, however, exclusively Palæarctic; but on the American side, from Vancouver's Island to Lower California, is found another species, *L. occidentalis*, Audubon, a gull with a very dark mantle, no pattern on the outer primaries, and a short stout bill; this is an exclusively American form, but it is clearly a member of this group.

With the same range as *L. occidentalis*, and restricted, like it, to the western side of the North Pacific, is found *L. californicus*,

Lawr., the largest member of the group of which *L. zonorhynchus*, Ord, is its nearest ally in the Nearctic region; and again, over a similar area is found *L. brachyrhynchus*, Richards., the close ally and representative in North-western America of *L. canus* of the whole Palæarctic region from Europe to Japan. These three species seem to keep to their respective sides of the North Pacific; and if we except stragglers of *L. californicus* and *L. zonorhynchus* to Japan, and of *L. canus* to Labrador, these inhabitants of the Nearctic and the Palæarctic regions do not appear to overlap; nevertheless the North Pacific is the only area within which they are *all* found, and seems in this case also to be the point of dispersal. This brings us to the consideration of another natural group, the members of which occur throughout the whole of the Pacific, both north and south, but more particularly in the latter.

In the typical Gulls the barred tail is a mark of immaturity, and the hood is usually the sign of breeding plumage; but there is a group in which these conditions are partially or entirely reversed. The coasts of China and Japan are frequented by *L. crassirostris*, Vieill., a medium-sized gull, which has a slight tendency to a brownish hood when young, but which in the *adult* state has a pure white head and underparts, a dark grey mantle, and a tail crossed by a broad black bar. On the Californian side is found *L. heermanni*, of about the same size, with a still more distinct hood in the immature stage, with more black on the tail, and underparts of a sooty grey colour, which fades away on the head into a pale grey in the fully adult. Yet further south, on the coasts of Peru and Chili, is *L. belcheri*, Vigors, a stout-billed gull, with a very marked hood in the early stage, but which when adult is much like *L. crassirostris*, except that its mantle is decidedly black. On the same coasts occurs a much slenderer and more elegant species, *L. modestus*, Tsch., with rather delicate tarsi; this also has a decided hood when immature, but in the adult the dark grey of the underparts fades into a pale colour, and becomes almost white on the head and forehead. In the Galapagos archipelago, and nowhere else, is found a much stouter and coarser gull, *L. fuliginosus*, Gould, of a nearly uniform sooty hue, and bearing a hood in the adult as well as in the immature plumage. At the very extremity of the district, and extending some distance beyond it, ranging from the Straits of Magellan to the Falklands and South Shetland Islands, comes an aberrant species, of which it can only be said that its

affinities are more with this group than with any other. This is *L. scoresbii*, Traill, a gull with a remarkably short, stout, crimson bill, coarse feet, with somewhat excised webs, and a decided hood in the immature stage, whilst in the adult plumage the head becomes light coloured as in the rest of the group, from which, again, it differs in having a white tail like an ordinary adult gull. Passing to the extremity of the opposite side of the South Pacific, we find in Tasmania, and perhaps in New Zealand, a very large black-mantled gull with an enormously deep bill, *L. pacificus*, Lath., which, whilst in some points resembling the typical gull, *L. dominicanus*, to be considered next, has also a black band across the tail, which seems to indicate a relationship to the Pacific group. As regards *L. dominicanus*, Licht., it is an ordinary black-mantled, stout-billed gull, with an extensive range, reaching from New Zealand through Kerguelen and the intermediate islands to South Africa, and thence to South America on both sides nearly up to the tropic of Capricorn. So far as the southern hemisphere is concerned it stands alone; and perhaps its closest ally is the species *L. marinus* of the northern hemisphere, although the interval between their ranges is considerable. To avoid recurrence to the latter species, it may be as well to indicate its range here. The Great Black-backed Gull, *L. marinus*, the largest of all the family, is found throughout the greater part of the Palæarctic and Nearctic regions, more especially in the North Atlantic. In its wing-pattern it differs from any other large gull, and it is by no means closely allied to the Lesser Black-backed Gull, *L. fuscus*, which is also confined to the northern hemisphere, but has a less extended range, being only found along the shores of Europe, the Mediterranean, and the Red Sea and vicinity, not reaching to the Pacific seaboard of China, nor to the American side of the Atlantic. The latter is a long-winged elegant species, with yellow legs and a comparatively small foot, and is apparently closer to *L. affinis*, Reinh., than to any other.

Returning to the southern hemisphere, we find there a small and isolated group, all the members of which are very closely allied. In New Zealand the representative is *L. scopulinus*, Forst., a small gull with grey mantle, head, tail, and underparts white, and red bill and feet. In Australia, Tasmania, and New Caledonia it is replaced by *L. novæ-hollandiæ*, Steph., which merely differs from it in its slightly larger dimensions and a trifling variation in the pattern of the primaries. Then, without a link in the

chain, for no similar gull occurs on Kerguelen or any of the intermediate islands, a closely allied, but perfectly separable species, *L. hartlaubi*, turns up at the Cape of Good Hope. New Zealand also produces another species, *L. bulleri*, Potts, belonging to the same group, but varying rather more in its wing-pattern from *L. scopulinus* than that species does from the other two. *L. bulleri* seems to be rather a frequenter of inland waters, but all the others are *sea*-gulls, and, as has been observed, they form an isolated group. Bonaparte united them in the same subgenus with *L. gelastes* of the northern hemisphere; but the resemblance between them seems to me to be extremely superficial.

It is generally admitted that at one time Europe was united to Northern Africa at the Straits of Gibraltar, and again at Cape Bon in Sicily, the present Mediterranean sea being then divided into two great lakes. These barriers have long been broken down, yet there exists a gull which even now scarcely strays beyond the ancient limits of one of these inland lakes. This species is *L. audouini*, Payr., a long-winged bird similar to and nearly as large as a Herring-gull, but with black legs and a cherry-red bill crossed by a double transverse zone, its headquarters being in the vicinity of Corsica and Sardinia, and its occurrence has never been authenticated beyond Spain on the one hand, and Sicily on the other. There are scarcely two other species which have so circumscribed an area, and in a *sea*-gull this isolation is very remarkable. On the same waters, but with an extension of range as far as the Black, Caspian, and Red seas, and thence to Scind, is found *L. gelastes*, a slender gull, which, although devoid of a hood at all seasons, has close affinities with those species which bear a coloured hood in the breeding-season only, and which have next to be considered.

The typical Hooded Gulls are, with one exception, small or medium-sized birds; and as regards number of species, the group is better represented in the northern hemisphere than in the southern. Indeed the whole of the south-eastern portion of the globe can show but one solitary species, *L. phæocephalus*, Sw., a South-African form with a pale grey hood, closely allied to, and, in fact, only just separable from, *L. cirrhocephalus*, Vieill., which inhabits the opposite coast of Brazil and the Rio de la Plata States, and has also, strange to say, been twice obtained on the Pacific near Lima. How it gets there is not known, the interval being absolutely unbridged, but the fact is undoubted. The African species is probably an offshoot of the American form, inas-

much as beyond the Neotropical district no other hooded gull is known to exist in the southern hemisphere. The Neotropical region, which has been so well worked out by Messrs. Sclater and Salvin, possesses three other indigenous species, two of which, *L. maculipennis*, Licht., and *L. glaucodes*, Meyen, only differ in a slight degree in the pattern of the wing-feathers. Their geographical distribution is, however, somewhat remarkable—the former ranging from South Brazil down to South-eastern Patagonia, where it stops, its place being taken from the Falkland Islands round to Chili by *L. glaucodes*. At the first glance, both these species much resemble our well-known *L. ridibundus*, L., of the Palæarctic region, and they appear to be its southern representatives. Along the Andean range from Chili to Ecuador is found a much larger and handsome species, *L. serranus*, Tschudi, which breeds on the shores and islands of the Lake Titicaca and other lakes at a considerable elevation, only visiting the Pacific coast during the bad weather in the mountains. Any other Hooded species found in this region are merely winter visitants from the north, and the most abundant of these is *L. franklini*, a Subarctic species which breeds in the Fur countries, and ranges through North America west of the Mississippi, Mexico, and down the Pacific coast to Chili. Of the remaining two American species, *L. atricilla*, L., which has black primaries, inhabits the temperate and intertropical regions of the Atlantic and Pacific coasts; and *L. philadelphiæ* (Ord), (*L. bonapartii*, Rich.), ranges right across Subarctic America, descending both coasts, an immature straggler occasionally finding its way to the British Isles.

In the Palæarctic region, *L. ridibundus*, L., is found throughout its whole extent, descending in winter as far as 15° N. lat. On the Indian coast it then impinges upon the domain of its stouter relative *L. brunneicephalus*, Jerd., a species which has its summer home in the lakes of the lofty tablelands of Tibet and Mongolia. Straggling along the Atlantic coast, but in the main confined to the Mediterranean and Black seas, is *L. melanocephalus*, Natt.; whilst that giant amongst the black-headed gulls, *L. ichthyaëtus*, ranges from the Mediterranean to the Bay of Bengal. Along the coasts and over the inland waters of China and Mongolia is found a very peculiar gull, *L. saundersi*, with which my lamented friend the late Mr. R. Swinhoe did me the honour of associating my name: it has remarkably slender feet and tarsi, resembling those of a marsh-tern, with a very stout and powerful bill. The smallest of all the gulls, *L. minutus*, Pall., ranges over the whole Palæ-

arctic region; and in its immature plumage, and in the pattern of its primaries when adult, seems to have no very close allies. In the Red Sea are found two species, the more specialized of which, *L. leucophthalmus*, is restricted to those waters, whilst *L. hemprichii* extends its range as far as Scind; like *L. atricilla* of America, they have black primaries, but there are no other points which ndicate any special affinity. To sum up the evidence afforded by the distribution of the Hooded Gulls, it cannot be said to amount to much more than a general indication of an origin in either the Palæarctic or Nearctic region, probably the latter, as it is from thence that they have been diffused fas ar as the extreme southern limits of the American continent.

The genus *Pagophila* calls for little remark: it contains but one species, the Ivory Gull, *P. eburnea*, and is a well-marked, coarse, and purely Arctic form, ranging from Novaya Zemlya to Spitzbergen and Baffin's Bay, but not being as yet recorded from any part of the North Pacific. Another purely Arctic form, the small Wedge-tailed or Ross's Gull, *Rhodostethia rosea*, Macgill., of which only thirteen specimens are known to exist, has a still more circumscribed range, and its head-quarters appear to be Melville Peninsula, Boothia Felix, and perhaps the region between Spitzbergen and Franz-Joseph land. This beautiful species when in breeding-plumage has a black collar but no hood, the underparts being tinted with a rich rose-colour, whilst the centre feathers of the tail are somewhat prolonged as in the Skuas, from which group, however, it is in all other respects far removed. This also is an Arctic species with no near allies. The last of the Arctic species is *Xema sabinii*, a gull but slightly larger in size, with a black hood deepening into a collar, and a *forked* tail. This gull breeds right round the Arctic circle from Greenland to the Siberian tundras north of lat. 74°, and has been known to push its southern migrations as far as the north of Peru. There is considerable interest attaching to this wanderer in the tropical Pacific; for at Chatham Island, one of the Galapagos group, and situated nearly on the Equator, was obtained one of the two existing specimens of that rarest of all gulls, *X. furcata* (Neb.)—a fork-tailed hooded species, which, but for a few trifling details, is a gigantic *X. sabinii*. Over the real habitat of *X. furcata* there hangs a slight mystery. There can be no doubt the specimen in the British Museum was obtained in the Galapagos group, the very rock (Dalrymple rock,

Chatham Island) is indicated; the plumage seems to be that of maturity, and the date accords with what that plumage ought to be. The other specimen, which is in the Paris Museum, is stated by Neboux to have been obtained at Monterey, California, during the cruise of the 'Vénus'; but that frigate also visited the Galapagos, and there may be a mistake in the locality, as Mr. O. Salvin has shown that such errors have occurred with other birds. This supposition is favoured by the fact that the American naturalists have kept a keen but unavailing look-out for it during many years past; and as the Galapagos group is seldom visited except by whalers and an occasional British man-of-war, it seems probable that this is another of those forms which are not merely confined to that archipelago, but even to a few islands of it. Under these circumstances it is interesting to find that its nearest ally comes at times so close to its domain; and this approximation in the Pacific is another link in the chain of evidence respecting the centre of dispersion.

These Fork-tailed Gulls lead in a manner to the subfamily of Terns (*Sterninæ*), although there is a tolerably wide gulf between them, as shown by the shape of the bill, the short feet and tarsi, and the long wings, the latter pointing to increased adaptation for prolonged flight. Accordingly we find that, as a rule, there are fewer specialized forms than in the *Larinæ*, and that the range of the majority of the species is wider than in the same proportion of the Gulls. This is mainly due to the conditions of their existence, which depend on fish and aquatic productions; but even under conditions so favourable to dispersion, there are not wanting some remarkable instances of isolation. Of the larger and heavier species, the largest, *Sterna caspia*, although nowhere numerically abundant, has an immense range, being found breeding from the Nearctic and Palæarctic regions down to New Zealand, although replaced throughout intertropical America and on the west coast of Africa by the somewhat smaller and more elegant *S. maxima*, Bodd. *S. cantiaca* has a western Palæarctic and eastern Nearctic range, going to the Cape of Good Hope in winter, as do also both *S. fluviatilis* and *S. macrura*, Naum., our Common and Arctic Terns, which have a more extended range in the north, whilst none of them are known to breed in the southern hemisphere. From the Mediterranean to the Malay Archipelago and Torres Straits is found *S. media*, the Old-World representative of *S. elegans* and *S. eurygnathus* of tropical America; whilst from

Africa to Australia and Polynesia we find a large Tern only differing from the usual style of coloration in having a white frontlet band at the base of its bill, and which, in spite of local variations in size and colour of mantle, seems to me to be but one species, *S. bergii*, Licht. It would be tedious to enumerate all the typical species and to give their respective ranges; but there is a point in the distribution of some of those in the southern hemisphere which must not be passed over. On the coasts of Chili, the Straits of Magellan, and the Falkland Islands is found *S. hirundinacea*, Less. (*L. cassini*, Sclater), rather larger than our Common Tern, *S. fluviatilis*, and having a bright red bill. At Tristan d'Acunha, and thence to St. Paul's and Amsterdam Islands, and down to Kerguelen Island, we find a very similar Tern, *S. vittata*, Gm., but smaller and with the underparts washed with grey, closely resembling, in fact, our Arctic Tern, *S. macrura*, but having a longer tarsus. The Tristan d'Acunha bird is undoubtedly *S. vittata*; but its connexion with *S. hirundinacea* is shown by a visibly closer approach to that species than is the case in St. Paul's or Kerguelen-Island examples. At Kergulen Island is also found an affined but quite separable species, *S. virgata*, Cab., of a more uniformly sooty hue, but still presenting the characters of an *oceanic* tern in its pointed red bill and elongated tail-feathers; this species is absolutely confined to that island. Passing to New Zealand, we meet with very similar species, *S. antarctica*, Wagler, in which the shape of the bill is somewhat modified, becoming short, stout, and considerably curved in the upper mandible, the webs of the feet are also more excised—peculiarities which have led to its being placed by some systematists in the genus *Hydrochelidon*, with which, however, it has no real affinity. Here the chain breaks abruptly, there being beyond this point no connexion with South America to complete the circle. As the northern representatives of these Antarctic species come down, in winter at least, as far as South Africa, the point of union seems in this case to be the South Atlantic; but when and why the separation took place in their breeding-range it is impossible to say. New Zealand also possesses one isolated species, *S. frontalis*, a rather larger Tern with a white frontlet, apparently more closely connected with *S. cantiaca* than with any other.

From the Red Sea to the Laccadive Islands is found another of these specialized forms, *S. albigena*, a slender species of the Common Tern type, but washed all over with a sooty hue. Another mem-

ber of the same group, *S. dougalli*, has a very wide range, reaching from temperate America and Europe to South Africa, Ceylon, and the Andaman Islands, where it breeds, even to the northern coasts of Australia. All these are typical species so far as shape and the black crown to the head are concerned; but from China and the Andamans to Torres Straits and Eastern Polynesia we find *S. melanauchen*, an oceanic species which has only a black band from the lores to the nape, the crown being white; this, again, is an isolated form. In South America, from Brazil to Chili, there is another species, *S. trudeaui*, which is singular in having no crest, but only a dark streak from the eye to the ear and a party-coloured bill.

Of the group of Little Terns, of which *S. minuta* is the type, there are several species, respecting which it need only be said that the variations comprise the typically marked *S. balænarum* of South Africa, with a full black crown with white lores, *S. minuta*, with only a partially black crown with black lores, and *S. nereis* of Australia, with uncoloured lores and a partially black crown. Their distribution gives no clue to their point of dispersion. Neither are the three species of Marsh-terns comprised in the genus *Hydrochelidon* of much use; they are probably Old-World forms, having a wide range north and south. Only one, the Black Tern, *S. nigra* (L.), is found in America as well as in the Palæarctic region, the other two, *H. hybrida* and *H. leucoptera*, ranging as far as Australia and New Zealand. *Sterna anglica*, placed by some systematists in the genus *Geochelidon*, and the River-terns, *S. seena* of India and *S. magnirostris* of Tropical America, need no special remarks.

Returning once more to the North Pacific, we find a remarkable and very local form in Alaska, *S. aleutica*, which has a white frontlet, black lores, a dark crown, and a dark grey mantle, the underparts being washed with grey. Looking at the head alone, it presents the markings of one of the group of Sooty Terns which have been placed by Wagler in three distinct genera, *Onychoprion*, *Haliplana*, and *Planetis*, all based upon the same identical species! It differs, however, from all Sooty Terns in having the rump and tail pure white, in which respect it resembles the bulk of the Nearctic and Palæarctic species, whereas in the Sooty Terns the rump and tail are dark like the mantle. At present it is separated by an interval of upwards of 20° of latitude from any of the Sooty Terns, of which there are three species, all wide-ranging and intertropical; but it is impossible to avoid considering it an important link in the chain of descent, the other com-

ponent parts of which are missing. This view is strengthened when it is observed that from the Moluccas throughout part of Polynesia is found its nearest ally amongst the Sooty Terns, namely *S. lunata*, a species in which the upper parts are dark grey instead of black as in *S. fuliginosa* and *S. anæstheta*. Here, again, the Pacific seems to be the point of departure.

On the coasts of Peru and Chili is found a very remarkable species, *Nænia inca*, typical as regards its forked tail, but raised to generic rank on account of its long, curved, projecting feathers resembling moustaches, and the union of the foot with the hallux. It is believed to be a rock-breeding species, but little is known about it. A still more highly specialized form is the snow-white *Gygis*, which has long slender toes, with deeply excised webs, and a graduated tail, the second or third feathers being the longest, in which respect it is allied to the Noddies (*Anous*). *Gygis candida* ranges from Ascension, St. Helena, Madagascar, Mauritius, &c. to Australia, and thence through Polynesia up to the Sandwich Islands: at the Marquesas is also found a smaller and slender-billed form, which I consider entitled to specific distinction, *G. microrhyncha*. The nidification in this genus is very peculiar, the single egg being placed in any trifling depression in the surface of the branch, or in a fork of a tree or even of a stout plant. In making no nest these birds resemble the majority of the *Sterninæ*; but the shape of the tail points to a relationship with the members of the genus *Anous*, the nearest being with the two small grey Noddies, *A. cæruleus* (Bennett), and *A. cinereus*, Gould, which appear to be almost if not entirely confined to the coral-islands of the Pacific, where they deposit their single egg in the crevices of the rocks, making no nest. Next comes a nearly black Noddy with a white crown, *A. leucocapillus*, Gould, confined to the islands between the Paumatu group and North Australia, which also seems to make no nest. The record respecting these and the two following species is, however, very imperfect, and it is not safe to base any deduction upon what is at present known of their distribution. *A. melanogenys*, Gray, with deep black lores and greyish nape, is a widely-distributed species, being found from Honduras down to Australia and Polynesia. The most remarkable fact about its range is that the 'Challenger' Expedition obtained it at Inaccessible Island close to Tristan d'Acunha, in 37° S. lat., the home of the penguin, the albatross, and other sub-antarctic species, where the even more widely-diffused Common

Noddy, *A. stolidus*, was also found. These two species make a substantial nest of seaweed, and place them on trees, bushes, and rocks. Of *A. tenuirostris* (Temm.), I can only say that it seems to have been obtained at Senegal, the islands of Rodriguez and Mauritius, and the west coast of Australia: it differs from *A. melanogenys* in having grey lores and face; but much more information is requisite respecting it before its range can be mapped out with any approach to accuracy.

Of the Skimmers (*Rhynchopsinæ*), which have the general appearance of Terns with a remarkable projecting under mandible, there are three species separable by their plumage alone. In habits and nidification they are alike, frequenting the banks of large rivers, and depositing their eggs on the sand. The most distinct is naturally *R. nigra* of Tropical America; *R. flavirostris* of Egypt and the Red Sea, and *R. albicollis* of India, being more closely related. The American species ranges from New Jersey, along both sides of America down to 45° S. lat., and its complete isolation from its two close allies is very peculiar.

It is, then, in the North Pacific that we find the majority of the typical *Larinæ*, and it is there alone that the Arctic and white-primaried forms are connected through *L. glaucescens* with the group which have distinctly barred primaries, almost all the members of which are also found there. It is only in the North Pacific that we can see where the three-toed *Rissa* began to deviate from the typical four-toed Gulls, and it is only there that a faint line of connexion can be traced between the only two species which have forked tails (*Xema*). It is only along the Pacific coasts that the continuous chain can be followed with the typical Hooded Gulls, of which *L. ridibundus* is the Palæarctic representative, and which in *L. glaucodes* reaches unbroken to the Straits of Magellan, whilst in the eastern hemisphere it cannot (with the solitary exception of the South-African *L. phæocephalus*) be found south of 10° N. lat. It is again only in the North Pacific that we find the peculiarly-coloured tern *Sterna aleutica*, which so clearly connects the typical *Sternæ* with the intertropical Sooty Terns, *S. lunata*, *S. anæstheta*, and *S. fuliginosa*. It is not necessary to lay much stress upon those Pacific gulls which, with slight modifications, have barred tails at all ages and a hood in the immature stage, for there the chain is more broken; and the majority of the *Sterninæ* are also so wide-ranging that their distribution teaches

us but little, although even here the links which unite *S. hirundinacea* of South America with *S. antarctica* of New Zealand, by way of the Southern Ocean, are very interesting. The distribution of the Skuas or Parasitic Gulls seems also clearly to connect the northern and southern hemispheres by way of the Pacific. It is, in fact, easier to specify the isolated groups which have *no* apparent connexion with the Pacific, foremost amongst which is that comprising the New-Zealand *L. bulleri* and *L. scopulinus*, the Australian *L. novæ-hollandiæ*, and the South-African *L. hartlaubi*. In the Arctic region there are the two isolated and specialized genera of Gulls, *Pagophila* and *Rhodostethia*, which are not known on the Pacific side; whilst amongst the Terns the intertropical genera *Nænia*, *Anous*, and *Gygis*, although somewhat related *inter se*, offer no particular points of union with the typical *Sterninæ*. It is admitted that the present record is necessarily very imperfect, but it seems to me that the bulk of the evidence indicates the North Pacific as the centre of dispersal; and whether this view be accepted or not, I trust that the points to which I have drawn attention may at least show that Mr. A. R. Wallace's statement that the *Laridæ* are of little use in the study of geographical distribution is capable of a slight modification.

On the Action of Limpets (*Patella*) in sinking Pits in and Abrading the Surface of the Chalk at Dover. By J. Clarke Hawkshaw, M.A., F.G.S. (Communicated by Dr. J. Murie, F.L.S.)

[Read April 18, 1878.]

(Abstract.)

The surface of the chalk which is exposed between high- and low-water mark on the foreshore to the east of Dover is covered by a series of small and finely grooved hollows made in the substance of the chalk. These abrasions of the surface are made by the limpets when feeding on the coating of delicate seaweed which covers the surface of the chalk.

When the rock has a good coating of this seaweed, the proceedings of any single limpet may be well seen. The lingual teeth make a small scoop or groove in the chalk; and as the animal makes a number of grooves one beside the other, a line is produced. After the limpet has completed a line, which is curved

with the concave side towards the animal, it reverses its action and makes another curved line, in which each new groove is made to the left of the last one. The first and second lines meet at a more or less acute angle; so the limpet moves over the ground making curved lines in alternate directions, which form a zigzag. Sometimes the angle which the curved lines make with one another is so small, and the lines are consequently so close together, that all, or nearly all, the surface of the chalk is subjected to the grooving. In such cases patches of freshly abraded chalk more than an inch square in area represent the work of a limpet probably in one tide. In other cases, when the animal had moved more rapidly over the ground, the result of such an excursion appeared in an open zigzag line. In these cases the length of the path of the animal was sometimes more than 12 inches—the length of the curved lines forming the zigzag being $\frac{3}{4}$ of an inch, and the width $\frac{1}{16}$ of an inch, but varying from that downwards, according to the size of the animal by which they were made.

On the part of the chalk foreshore immediately to the east of Dover, which is generally free from great inequalities or débris, limpets are very abundant, almost to the exclusion of other shell-fish; and down to near low-water mark there is little or no sea-weed, excepting the young growth, which appears to be removed with part of the surface on which it grows soon after it appears. The number of limpets to a square foot varied, in the few cases in which I had time to count them, from 5 to 9, omitting small ones less than about half an inch. Further to the east along the shore, where there has recently been a fall of the cliff, the shore is encumbered with blocks of chalk. Many of these blocks were covered with a matted coating of fine, semitransparent, ribbon-like seaweed. The limpets had not yet obtained a footing here; but I found one or two, conspicuous by the little clearing they had made in the midst of the seaweed. It was here possible to ascertain the area of surface which one limpet could abrade and keep clear of any but the youngest growth of seaweed. I measured some of these bare patches, and found them to vary from 8 to 14 square inches in area. The whole surface of these patches was closely grooved, the less recent work being covered with an incipient growth of seaweed. If one limpet could keep clear 14 square inches, it would require ten to keep clear a square foot, which agrees with my former estimate (small ones being omitted) of nine to a square foot where the rock was grooved all over.

It is not easy to estimate the amount of chalk removed by

limpets in the course of a year; but they must repeat the abrading process many times if they can, as some do, confine their operations to a few square inches of surface. Some of the best-defined grooves which I measured were $\frac{1}{50}$ of an inch in depth; but I think that the limpets in grazing over a surface which has been previously grooved have a tendency to deepen the first-made grooves in the centre; and if so, the above depth might be the result of several operations. As nearly as I can estimate it, the depth of chalk removed on a fresh surface is about ·006 of an inch; so that if we suppose the limpets to feed over the same area of surface ten times in a year, the total depth of chalk removed will be ·06, or about $\frac{1}{17}$ of an inch. In any case they do more to destroy the rock-surface than the sea ordinarily does. If this were not the case, the action of the sea would obliterate the marks made by the limpets, which it does not; for the surface of the chalk is free from the marks or grooves only along the base of the cliffs where the shingle is washed about by the waves, and in a few holes and gullies where loose pebbles are rolled to and fro.

The limpets do a great deal of apparently unnecessary work in rasping away so much chalk; but it may be beneficial to them in preventing the settlement of sedentary rivals, such as *Balani* or the larger seaweeds, and so enabling them to keep a large surface of pasture-ground to themselves. The rasped surface seems to be soon covered again by the fine green coating on which, I presume, they feed. They rasp close round any hard object, such as a piece of shell or flint imbedded in the chalk; so that any *Balanus* or other sedentary growth would be left on an exposed pedestal of chalk, and, as the chalk is soft on the surface, would be liable to be washed off by the waves. On a large block of chalk which was tenanted by a quantity of limpets, so that every part of the surface was rasped over by them, I noticed one or two solitary *Balani*. The raspings extended close round the base of the shells of the *Balani*, and must have tended to weaken their hold on the rock. Yet a large proportion of the shells of the limpets had five or six large *Balani* on them. It would appear probable from this that there was something which made the chalk an unsuitable resting-place for *Balani*; and the action of the limpets may not unlikely be the cause. The limpets certainly had the foreshore almost entirely to themselves down to low-water mark. These comparatively large areas of rock-surface covered only by a short vegetable growth, and browsed over by

limpets, remind one, in a small way, of the llanos or pampas on the land, where arboreal vegetation is kept down by herbivorous animals. Yet the limpets appear to do their work more effectually, as they uproot all alien growths.

The holes in the chalk, in which the limpets are often to be found, are, I believe, excavated in a great measure by rasping with the lingual teeth, though I doubt whether the object is to form a cavity to shelter in, though the cavities, when formed, may be of use for that purpose. It must be of the greatest importance to a limpet that, in order that it may ensure a firm adherence to the rock, its shell should fit the rock accurately; when the shell does fit the rock accurately, a small amount of muscular contraction of the animal would cause the shell to adhere so firmly to a smooth surface as to be practically immovable without fracture. As the shells cannot be adapted daily to different forms of surface, the limpets generally return to the same places of attachment. I am sure this is the case with many; for I found shells perfectly adjusted to the uneven surfaces of flints, the growth of the shells being in some parts distorted and indented to suit inequalities in the surface of the flints. As the edges of the shells, especially those of the younger animals, are very sharp, the effect of pressure brought to bear on the edge, either by the contraction of the animal or by the shock of the waves, would, if there is the least sideway movement, be to cut into the chalk round the edge of the shell. The muscles of the animal are generally relaxed when reposing; for if the point of a knife be quickly inserted beneath the edge of the shell, it may be detached from the rock without difficulty; but if the least warning by a touch be given to the animal, its muscles contract, and it adheres so firmly that it is impossible to detach it without breaking the edge of the shell*. These alternate relaxations and contractions on sudden alarms would tend to increase the effect of the cutting action of the edge of the shell. I saw the fine indentations round the edge of some of the shells exactly reproduced upon the surface of the chalk; and this could only result from pressure on the shell forcing its sharp edge into the chalk. A very little pressure, as may be found by trial, will suffice to force the edge of the shell into the chalk. The effect of the formation of a groove in the chalk corresponding with the edge of the shell

* Reaumur found that a limpet could sustain a weight of from 28 to 30 pounds for some seconds (Jeffreys, 'Brit. Conch.' vol. iii. p. 232).

would be to diminish the internal capacity of the shell, and possibly to cause discomfort to the animal, or prevent its obtaining a firm hold on the rock. As all the surface of the chalk outside the shell becomes covered with the fine growth of seaweed, the outer side of the groove round the edge of the shell, which forms the side of the pit, becomes in like manner covered with seaweed, and is pared away to a slope. This assists the cutting effect of the edge of the shell, as it is more effective against the foot of a slope than it would be if the face of the pit were perpendicular. I noticed one case in which a limpet appeared to have pared away one side of the pit, that opposite the head of the animal, as fast as the pit had been sunk. The animal had begun to browse from the edge of the shell outwards.

The above appears to me to be an explanation of the manner in which the habit of sinking pits may have been acquired by limpets. But in many cases they now appear to excavate deeper pits than would be required for the removal of the protuberance, extending the excavation below the plane of the rim of the shell. For what purpose this is done I do not know, unless it be to get a clean surface of chalk to adhere to, as their slimy bodies would detach pieces of chalk in time, and possibly render their hold less secure. Small pieces of chalk do adhere to the animals when you remove them from the rock. These hollows which they excavate below the plane of the rim of the shell are, when completed, basin-shaped, sloping away from the edge of the shell. At first they are begun beneath the head of the animal, and a considerable hollow is often made there before the excavation is extended round the sides backwards. During the process of excavation a lump is left in one stage in the centre.

When a limpet has sunk some distance into the chalk by the above processes combined, the pits are further enlarged by smaller limpets sinking secondary ones and browsing on the seaweed which grows on the sides of the pits.

I noticed signs that limpets prefer a hard smooth surface to a pit in the chalk. On one face of a large block, over all sides of which limpets were regularly and plentifully distributed, there were two flat fragments of a fossil shell about 3 inches by 4 inches, each imbedded in the chalk. The chalk all round these fragments was free from limpets; but on the smooth surface of the pieces of shell they were packed as closely as they could be. I noticed another case which almost amounts, to my mind, to a proof that they prefer a smooth surface to a hole. A limpet had

formed a clearing on one of the seaweed-covered blocks before referred to. In the midst of this clearing was a pedestal of flint rather more than 1 inch in diameter, standing up above the surface of the chalk: it projected so much that a tap from my hammer broke it off. On the top of the smooth fractured surface of this flint the occupant of the clearing had taken up its abode. The shell was closely adapted to the uneven surface, which it would only fit in one position. The cleared surface was in a hollow with several small natural cavities, where the limpet could have found a pit ready made to shelter in; yet it preferred, after each excursion, to climb up on to the top of the flint, the most exposed point in all its domain.

In South America our limpets have, I believe, representatives with shells a foot in diameter. If the proceedings of these South-American giants are at all the same as those of the limpets of our own shores and are in proportion to their size, they must materially aid in the encroachment of the sea on the land when the rock happens to be soft *.

Notes on the Presence of *Tachyglossus* and *Ornithorhynchus* in Northern and North-eastern Queensland. By Capt. William E. Armit, F.L.S.

[Read June 20, 1878.]

Some doubt having been evinced of the existence of *Tachyglossus* and *Ornithorhynchus* in Northern Queensland, I am desirous of laying a few facts before the Society, which will establish the extreme northern limit of the species as far as yet known.

Tachyglossus occurs at Bellenden Plains, situated some thirty miles north-east of Cardwell, in about 18° S. latitude. It frequents the scrubs on the mountains and river-banks, and on one occasion, in 1873, I found the hind legs of one in a black fellow's "dilly-bag." At Georgetown, distant some 200 miles west of Cardwell, this animal is pretty common; and last year I succeeded in capturing three males. One adult female I secured in 1876, having a fine young one in the pouch. All the above speci-

* Subsequent to the reading of the foregoing, my attention was called to a paper by Fred. C. Lukis ('Mag. of Nat. Hist.' 1831, vol. iv. p. 346), wherein figures of limpet-tracks are given. Although I find that, independently, I corroborate his observations, nevertheless, so far as I can learn, the bulk of my facts and suggestions have not hitherto been dwelt on by previous writers.

mens were found by mere chance when on Wallaby shooting-excursions in the granitic hills near Georgetown. Had I chosen systematically to hunt for them, I have no doubt that twenty could have been procured in a fortnight; for I have seen their tracks and burrows almost everywhere round this township.

The female is said here to lay one egg, which is placed in the abdominal pouch and hatched *. The young thrusts its bill into the curious inverted nipple and expresses the milk. From observing a young male with softish quills, I am of opinion that it leaves the abdominal pouch as soon as the spines begin to cover its back, as these would no doubt wound the skin lining it. The males have only a thick muscular ring, which in the females expands into a large pouch during the breeding-season. The opening is diagonal, and back towards the hind quarters.

From the fact that I had to use some force to get the young out of the pouch, I think that the inverted nipple is supplied with a muscular ring which is contractile, and by which the animal is enabled to hold the bill firmly in the nipple.

* [Captain Armit would seem not to be conversant with Prof. Owen's researches on the Monotremata, especially his paper "On the Marsupial Pouches, Mammary Glands, and Mammary Fœtus of the *Echidna hystrix*," in 'Philos. Trans.' (Roy. Soc.), 1865, pp. 671–686, pls. xxxix.–xli. In this both curious and highly interesting information are given, not the least being the conflicting evidence of Australian observers. Whether the *Echidna* and *Ornithorhynchus* are brought forth alive or are the product of extruded eggs, is still an unsettled question: the anatomical data point to the former; those who have had the live animal in Australia insist on the latter. It behoves, then, that the further attention of those with opportunity in the field should be called to the desiderata in the life-history of these animals, as summed up by Prof. Owen, *l. c.* p. 682, and herewith quoted:—

"The chief points in the generative economy of the Monotremes which still remain to be determined by actual observation are:—1. The manner of copulation. 2. The season of copulation. 3. The period of gestation. 4. The nature and succession of the temporary structures for the nourishment and respiration of the fœtus prior to birth or exclusion. 5. The size, condition, and powers of the young at the time of birth or exclusion. 6. The period during which the young requires the lacteal nourishment. 7. The age at which the animal attains its full size."

Of the *Echidna*, pregnant females killed between 25th July and 7th August, and of the *Ornithorhynchus*, between 15th October and 15th November, Prof. Owen suggests, might yield material to explain No. 4 as above. The womb and all connected parts intact should be placed in strong spirit and forwarded to London for examination by competent authorities. Eggs, or supposed eggs, as laid, if promptly put in spirit and transmitted hither, would solve a disputed physiological problem of the highest interest.—EDITOR.]

Mr. E. B. Kennedy records the capture of a *Tachyglossus* at Plain Creek, in lat. 21° south. And, from information derived from one of my troopers, I am of opinion that it will be found on the Leichardt ranges, as also throughout the length and breadth of the Cape-York peninsula. The New-Guinea forms will, I think, vary (perhaps only slightly) from our Australian types, judging by Mr. Ramsay's description of *Tachyglossus lawesii* (Proc. Linn. Soc. New S. Wales, 26 March, 1877).

I forward, under separate cover, the head of an adult female killed at Georgetown, for comparison with the New-Guinea and South-Australian types.

I have not, as yet, been able to secure specimens of the *Ornithorhynchus*; but I watched one swimming about in a large water-hole situated 150 miles west of Georgetown on the road to Normanton. I distinctly saw this animal's head and bill above water, but was unable to capture it, as it dived on hearing the pack-horses trotting up to the hole to drink. My boys inform me that they saw this "funny fellow" in the Upper Herbert; and it occurs on the Leichardt river. The extreme northern limit is therefore at present formed by the 18° of south latitude.

The absence of *Tachyglossus* on the Flinders and Gilbert river-plains is easily accounted for by the absence of scrubs and hills, or rocks, under which they generally burrow. It never comes out to feed except during the night: and when attacked, simply rolls itself into a spiny ball. Four men, by taking one claw each, had considerable difficulty in stretching one out. They resemble a hedgehog in outward appearance, but are much darker.

Remarks on the Skull of the *Echidna* from Queensland. By Dr. J. Murie, F.L.S.

[Read June 20, 1878.]

Along with his paper, Capt. W. E. Armit was good enough to forward to the Society a roughly cleaned dried skull of the *Echidna* obtained by him, to which the following label was attached: "Head of *Tachyglossus* (*histrix*?) ♀, killed near Georgetown, in 18° S. lat., Nov. 1876." As, moreover, he has expressed a desire that it should be compared with those of South Australia and New Guinea, I have fulfilled this wish so far as circumstances permitted.

The skin and snout-membrane from the eyes forwards were intact; and the palatal membrane was also in a perfect state of preservation, though dried. Slight injury had been sustained in the bones of the left supraoccipital and postparietal region; but as tissue held this fractured area together, it did not materially interfere with the examination and comparison of the cranium. Having softened the hardened tissues by soaking the specimen in water for a few days, I could well make out the natural appearance of the nostrils and mouth and of the palate-ridges. These I made sketches of, and meanwhile compared the objects themselves with the excellent illustrations of Prof. Paul Gervais * of the *Echidna* of New Guinea, *Echidna* (*Acanthoglossus*) *bruijnii*.

The orifices of the nostrils of Capt. Armit's specimen are shorter and more triangular than in Gervais's sketch of those of the Northern New-Guinea animal. In this respect they rather agree with the representation given by Mr. E. P. Ramsay † of his *Echidna* (*Tachyglossus*) *lawesii* of Southern New Guinea; but they equally correspond, so far as I can make out, with the common Australian form, *E. hystrix*. I may note that there is a tiny elevation or nipple-like process at the posterior end of each orifice, which seems absent in *Acanthoglossus*, and, I believe, is not mentioned by writers as present in the older known species of *Echidna*.

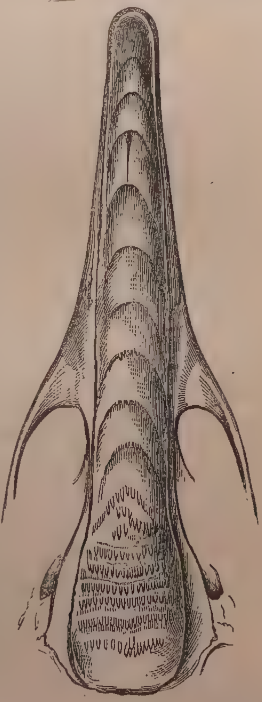
Prof. Gervais figures the mouth of *E. bruijnii* as longer and narrower, and with a decidedly more lanceolate lower lip than obtains in Capt. Armit's Queensland specimen, where, as in the common *Echidna*, upper and lower lips have a roundish contour and the oral opening short and relatively widish. In this Queensland *Tachyglossus*, from the tip of the snout to the angle of the mouth measures 0·4 inch; the width of mouth-opening 0·25 inch, and the snout width 0·35. In *T. lawesii*, Mr. Ramsay gives the corresponding dimensions as 0·45, 0·3, and 0·5 inch respectively. In *Acanthoglossus* the measurements are 0·8 inch, 0·2 inch, and 0·32 inch, as derived from Gervais's fig. 3, pl. vi. Thus the two former offer nearer approximations, and, while difing from the latter, agree with *E.* (*Tachyglossus*) *hystrix*.

As regards the character of the soft palate, Capt. Armit's specimen shows obviously, and at a glance, marked distinctions from that depicted in pl. vii. fig. 5 of Gervais's illustrations of the

* 'Ostéographie des Monotrèmes vivants et fossiles,' Atlas, plates vi. & vii.

† "Note of a Species of *Echidna* (*Tachyglossus*) from Port Moresby, New Guinea," Proc. Linn. Soc. of New South Wales, vol. ii. p. 31, and pl.

New-Guinea form. In this latter, according to him, rearwards there are five transverse lines of adnate conical papillæ lessening in the number of tubercles forwards, and in advance a dozen median linear, double, single, or rosette-like clumps. He remarks also that the palate of the Australian *Echidna* has seven serial transverse spiny lines bearing some resemblance to those of *E. bruijnii*. In the palate of the Queensland animal (woodcut) I find eight approximated, transverse, tuberculated rows posteriorly, and 0·3 inch in front of these another more arcuate,—that is, in all nine well-marked tuberculate cross ridges. Furthermore, there are eight somewhat scale-like cross arches, in one or two of which tracings of serrate free border is visible with a hand-lens. These latter are situate nearly equidistant, and about 0·2 inch apart, the hind one being opposite the anterior border of the orbito-zygomatic arch. The anterior palatine slit opens between the third and fourth front ones. Thus, of the New-Guinea and Queensland examples, both possess seventeen palatal ridges; but the pattern of these is unlike, that of the Queensland animal, to all intents and purposes, resembling that extant in the common *E. hystrix*.



Palate of Capt. Armit's *Echidna* from Queensland. Nat. size.

With respect to the cranium, I compared that from Queensland side by side with those in the College-of-Surgeons Museum, viz. five in all, intact. Of these specimens of *Echidna*-skulls, that numbered 1705 A is labelled *E. hystrix*, from Grafton, Clarence River, New S. Wales; No. 1708 A is that of a young male which lived in the Zoological Gardens; No. 1708 B is that of a complete skeleton of a young *E. setosa* from Tasman's Peninsula. Of No. 1705, *E. hystrix*, the locality is unrecorded; and No. 1704 A is marked in the Catalogue, "Skull of an *Echidna*." Moreover Prof. Flower lately has had added to the collection a cast of the skull of *Echidna* (*Acanthoglossus*) *bruijnii* (No. 1723 A), presented by Prof. Gervais.

The subjoined Table gives certain of the measurements in inches and deci-

mals, of the skulls in question; and it is to be noted that those in the first two columns are from less mature animals than the succeeding three.

Admeasurements of Echidna *crania.*

Catalogue numbers of skulls...	1705 A.	1708 A.	1708 B.	1705.	1704 A.	Queens-land.	New-Guinea coast.
Extreme length	3·6	3·8	3·9	4·1	4·15	4·2	7·9
Extreme breadth (temporo-parietal region)	1·65	1·65	1·8	1·8	1·8	1·7	2·3
Greatest vertical height.........	1·35	1·4	1·4	1·45	1·4	1·27	1·9
From tip of beak to front of orbit..............................	1·8	1·9	1·9	2·1	2·15	2·1	5·1

Now it will be seen that there is a nearly uniform relative proportion between the five skulls and that from Queensland, as can be distinguished from the New-Guinea cast in the right-hand column. Nay, it is hard to point out any characters, irrespective of similarity of dimensions, to separate the skulls, whether from Tasmania, New South Wales, or Queensland. For example, the closest inspection of the so-called *E. setosa* (No. 1708 B), from Tasmania, shows, one would say, perfect agreement in most details with Capt. Armit's Queensland specimen, though the former to the eye seems a shorter, broader, higher skull, with a slightly fuller temporal region, than does the latter. Again, the male skull of the *E. hystrix* (No. 1708 A), has somewhat shorter præ- and postpalatine fissures than 1708 B; questionably a matter of age or sex, though both are not from old animals. In 1704 A the anterior condyloid foramina are open and the palatine region generally broadish. In No. 1705, evidently a thoroughly old skull, judging from its solid osseous texture, both orbito-frontal and parieto-occipital regions are ample.

The female Queensland skull, almost exactly of the same length as those numbered 1705 and 1704 A, is barely appreciably narrower across the cerebral area, but decidedly lower in the same region. Whether this last feature is a matter of sex (it being from an adult female) or a tendency to variation, I am unable to say. At all events, it is a feature so trifling in its way that no argument can be drawn therefrom.

The lower jaw of this same Queensland skull is a pefect counterpart of those of *E. hystrix* and *E. setosa* compared.

It would be but a reiteration of the statements of Prof. W.

Peters and G. Doria *, of Prof. Rolleston †, of Mr. E. P. Ramsay, and of Prof. Gervais, to detail the widely marked differences which appertain to the skull of the Northern New-Guinea *Echidna*, *E.* (*Acanthoglossus*) *bruijnii*. Size, length and curvature of beak, &c. are appreciable at a glance, and cannot be mistaken.

On the skull of the Port-Moresby *Echidna*, *E.* (*Tachyglossus*) *lawesii*, no data are yet published to enable a comparison to be made.

I may say I regret the change of generic name from the well-known and established *Echidna* to that of *Tachyglossus*, which latter, Prof. Peters points out, has priority. I should prefer also that of *Proechidna* for *Acanthoglossus*, as incidentally hinted by Prof. Gervais (*l. c.* p. 43).

In conclusion, I would state that from the data which have come under my observation we cannot regard Capt. Armit's animal found in Queensland as offering any distinction from that of the wide-spread *Echidna hystrix*; and so far as skull alone is concerned, that termed *E. setosa* cannot positively be distinguished from *E. hystrix*. On this latter head and that of supposed exterior distinctive characteristics, I look forward to the continuation of Prof. Gervais's admirable memoir to furnish us with evidence of a more decisive nature than at present can be gathered from the scattered published data.

Capt. Armit's note seems to be useful in determining the animal's northern range in Australia. But I may add that I trust he will endeavour, by further investigations on the spot, to clear up those enigmas in the procreation and development of the Monotremes which I have mentioned in the footnote to his own paper.

* Ann. del Mus. Civ. di Sci. Nat. de Genova, 1876, tom. ix. p. 183, "Descrizione di una nuova specie di *Tachyglossus* proveniente della Nuova Guinea settentrionale."

† Report Brit. Assoc. 1877.

Notice of some Shells dredged by Capt. St. John, R.N., in Korea Strait. By J. Gwyn Jeffreys, LL.D., F.R.S., F.L.S.

[Read June 20, 1878.]

Our knowledge of the Invertebrata inhabiting the North-Pacific Ocean has been considerably advanced by Capt. St. John's dredgings in the Japanese and Korean Seas, as the publications of this Society will testify.

With respect to the Mollusca, I noticed in the 'Journal' (Zoology, vol. xii. 1874) certain species thus procured by that excellent naturalist in North Japan, which are identical with or varieties of European species; and Mr. Edgar Smith subsequently gave, in the 'Annals and Magazine of Natural History' (ser. 4, vols. xv. and xvi. 1875), a list of Gastropoda from the same source. Capt. St. John's last dredgings in the Strait of Korea have yielded a not less abundant and valuable harvest of Mollusca; and although I prefer having the species worked out by Mr. Edgar Smith, which he will doubtless do with his usual accuracy, I cannot refrain from adding some remarks on a few of these species, which I consider European or interesting in other points of view.

In my former paper on the same subject I ventured to express an opinion that certain species of Mollusca which are common to the North-Atlantic and North-Pacific oceans might have originated in high northern latitudes, and have found their way to Japan on the one side, and Europe on the other, by means of a bifurcation of the great Arctic current. This opinion has been now corroborated by Capt. St. John, who says, in his letter to me of the 8th June, 1878, "It seems to me that the Arctic current bifurcates, bringing similar species of Mollusca, and gradually depositing them along its course in the Pacific and Atlantic."

I have to return my thanks not only to Capt. St. John for so kindly placing these further dredgings at my disposal, but to Mr. J. T. Marshall, for having laboriously and carefully sifted the smaller material and picked out and assorted all the organisms from it.

BRACHIOPODA.

Terebratula caput-serpentis, *Linné*, var. septentrionalis.

Anomia caput-serpentis, *L. Syst. Nat.* ed. xii. p. 1153.

Terebratula caput-serpentis, *Jeffreys, British Conchology*, ii. p. 14, pl. i. f. 1; v. p. 164, pl. xix. f. 2.

Hab. Korea, 35 fathoms. Spitzbergen and Davis Strait to

Malta and the Adriatic; Jamaica; North-east America; Japan; Australia; New Zealand: low-water mark to 1180 fathoms.

Fossil. Pliocene and Post-tertiary: Coralline Crag; Scotland; Scandinavia; Belgium; South Italy; Azores.

Very variable in shape and sculpture. Many synonyms; I have noted seventeen.

CONCHIFERA.

ANOMIA EPHIPPIUM, *Linné.*

A. ephippium, *L. S. N.* ed. xii. p. 1150: *B. C.* ii. p. 30, pl. i. f. 4; v. p. 165, pl. xx. f. 1, *a–e.*

Hab. Korea, 54 fathoms; young. North Atlantic, from Iceland and Faroe Isles to Egypt; Black Sea; Madeira; N.E. America. Depth 0–1450 fathoms.

Fossil. Pliocene and Post-tertiary: Coralline Crag; Great Britain and Ireland; Scandinavia; Italy.

This polymorphous species has caused the manufacture of between thirty and forty synonyms.

PECTEN SIMILIS, *Laskey.*

P. similis, *Lask. Mem. Wern. Soc.* i. p. 387, pl. viii. f. 8: *B. C.* ii. p. 71; v. p. 168, pl. xxiii. f. 5.

Hab. Korea, 30–54 fathoms. Finmark to the Gulf of Egina; Madeira; Jamaica: 2–722 fathoms.

Fossil. Pliocene and Post-tertiary: Coralline Crag; N.W. Germany; Italy.

The Korean specimens are smaller than those of European seas, although otherwise undistinguishable. They are rather numerous, and consist of single or separate valves. A few of them (upper valves) are coloured and mottled or streaked exactly like European specimens; but they are generally white or colourless. A valve from Rasel Amoush, on the Tunisian coast, has the inside marked with radiating lines which resemble striæ; and I mistook it for a species of *Amussium* or *Pleuronectia.* See Rep. Brit. Assoc. 1873, p. 112.

This abundant species has several obsolete synonyms.

CRENELLA DECUSSATA, *Montagu.*

Mytilus decussatus, *Mont. Test. Brit. Suppl.* p. 69.

Crenella decussata, *B. C.* ii. p. 133, pl. iii. f. 4; v. p. 172, pl. xxviii. f. 6.

Hab. Korea, 35–51 fathoms. Spitzbergen; Greenland; Iceland; Scandinavia; North of England and Ireland, and Scotland; North Atlantic ('Valorous' Expedition, a fragment from 1750

fathoms); Mediterranean ('Porcupine' Exped.); N.E. America; N. Pacific (*P. P. Carpenter*): low water to 530 fathoms.

Fossil. Pliocene: Monte Pellegrino, Sicily (*Monterosato*). Post-tertiary: Fifeshire; Norway.

NUCINELLA OVALIS, *S. V. Wood.*

Pleurodon ovalis, *S. V. Wood in Ann. N. H.* 1840, p. 231, pl. xiii. f. 1.
Nucinella miliaris, *Mon. Crag Moll.* 1861, p. 73, tab. x. f. 4, *a–c*.

Hab. Korea, 40 fathoms; a single valve.

Fossil. Pliocene: Coralline Crag (*S. V. Wood*); Antwerp Crag (*Vanden Broeck*).

This remarkable little shell is certainly not the *Nucinella miliaris* of Deshayes, who repudiated Mr. Wood's identification of his Crag species with the Paris-basin fossil. But the present discovery in a recent or living state of a generic form supposed to have been long ago extinct is extremely interesting. *Pecchiolia* (or *Verticordia*) *acuticostata* and several other species are common to the Crag formation and the North Pacific. As the Eocene and Pliocene species are not the same, I fear Mr. Wood's remarks with respect to the capability of variation in species which may be descended from more ancient forms are not quite applicable to the present case.

This species is a member of the *Arca* family. I have retained the name "*ovalis*," originally given by Mr. Wood, although it is inappropriate, signifying "belonging to an ovation;" the name ought to have been *ovata*, meaning "egg-shaped."

LEPTON SULCATULUM, *Jeffreys.*

L. sulcatulum, *B. C.* ii. p. 201; v. p. 177, pl. xxxi. f. 4.

Hab. Korea, 35 fathoms; several valves. Guernsey; Jersey; Etretat; Tangier Bay; coast of Tunis and Adventure Bank; Sicily; Canary Isles: laminarian zone to 130 fathoms.

LASÆA RUBRA, *Montagu.*

Cardium rubrum, *Mont. Test. Brit.* p. 83, tab. xxvii. f. 4.
Lasæa rubra, *B. C.* ii. p. 219, pl. v. f. 2; v. p. 179, pl. xxxii. f. 1.

Hab. Korea, 35–40 fathoms; two or three valves and fragments. Greenland (*Mus. Copenhagen*) and Iceland to the Mediterranean and Adriatic; Canary Isles; North and South Pacific; Strait of Magellan; St. Paul and Amsterdam Isles: shore to 20 fathoms.

Fossil. Coralline Crag and South-Italian Tertiaries; Post-tertiary at Portrush and in Norway.

There are a few more or less obsolete synonyms.

KELLIA PUMILA, *S. V. Wood.*

K. pumila, *J. Sowerby, Min. Conch.* tab. 637. f. 3; *S. V. Wood, Mon. Crag Moll.* p. 124, tab. xii. f 15, *a*, *b*.

Hab. Korea, 36 fathoms; two valves. 'Porcupine' Exped., 1869, off the west of Ireland, 422 fathoms: 1870, between Falmouth and Gibraltar, 220–795 fathoms.

Fossil. Pliocene: Coralline Crag, Sutton. The figures in the 'Crag Mollusca' do not quite agree with the description, nor with specimens which Mr. Wood kindly sent me; the figures in 'Mineral Conchology' are excellent. Also Sciacca, Sicily (*Monterosato*).

This ought not to remain in the genus *Kellia.* I should be inclined to place it in Philippi's genus *Scacchia* as typified by *S. elliptica.*

AXINUS FLEXUOSUS, *Montagu.*

Tellina flexuosa, *Mont. Test. Brit.* p. 72.

Axinus flexuosus, *B. C.* ii. p. 247, pl. v. f. 6; v. p. 179, pl. xxxiii. f. 1, 1 *a*.

Hab. Korea, 30 fathoms; var. *polygona*, 54 fathoms: young specimens and valves only. Type and varieties: North Atlantic from Spitzbergen and Greenland to the Ægean archipelago and the Canaries; N.E. and N.W. America: 3–450 fathoms. 'Lightning' Exped., 550 fathoms. 'Porcupine' Exped. 1869, 3–630 fathoms; 1870, 5–1095 fathoms.

Fossil. Pliocene and Post-tertiary in Europe (including the Coralline Crag) and N.E. America.

Variable in shape, and therefore having several generic and specific names. The variety *polygona* is *Ptychina biplicata* of Philippi, and *A. obesus* of Verrill, according to G. O. Sars.

PANOPEA PLICATA, *Montagu.*

Mytilus plicatus, *Mont. Test. Brit. Suppl.* p. 70.

Panopea plicata, *B. C.* iii. p. 75, pl. iii. f. 2; v. p. 192, pl. li. f. 1.

Hab. Korea, 40 fathoms; a small single valve, but unmistakable. Upper Norway to Sicily and the Canaries, 5–300 fathoms.

Fossil. Pliocene and Post-tertiary: Red and Coralline Crags; Antwerp Crag; Monte Mario; Belfast.

Var. *carinata*=*Mytilus carinatus*, Brocchi,=*Arcinella carinata*, Philippi. Palermo, 32–43 fathoms (*Monterosato*).

Synonyms. Sphenia cylindrica, *S. V. Wood*; Saxicava fragilis, *Nyst*; S. rugosa, juv., *Forbes & Hanley*; Myrina oceanica, *Conti*.

Fossil. Pliocene: Val di Andona (*Brocchi*); Coralline Crag (*S. V. Wood*); Monte Mario (*Conti, Rigacci*); Ficarazzi (*Monterosato*)!

An allied species from the Korean dredgings (35 fathoms) is of a rhomboidal shape and more solid; and it has a sharper keel and transverse striæ or riblets. *Arcinella lævis* of Philippi, a Sicilian fossil, is perhaps my *Decipula ovata* from the 'Porcupine' dredgings of 1869, and from Osterfiord in Norway, as well as the *Tellimya ovalis* of Prof. G. O. Sars from the Loffoden Isles. See Friele, 'Bidrag til Vestlandets Molluskfauna,' in Vidensk. Forh. for 1875; and Sars, 'Bidrag til Kundskaben om Norges arktiske fauna,' 1, Mollusca (1878), Suppl. p. 341, t. 33. f. 1, *a–c*.

SAXICAVA RUGOSA, *Linné*.

Mytilus rugosus, *L. S. N.* ed. xii. p. 1156.

Saxicava rugosa, *B. C.* iii. p. 81, pl. iii. f. 3; v. p. 192, pl. liii. f. 3, 4.

Hab. Korea, 30–54 fathoms; young. Apparently world-wide in its distribution, from low water to 1622 fathoms.

Fossil. Miocene, Pliocene, and Post-tertiary, throughout Europe (including the Coralline Crag), Northern Asia, and N.E. America.

Synonyms, both generic and specific, numerous.

GASTROPODA.

PUNCTURELLA NOACHINA, *Linné*.

Patella noachina, *L. Mant. Plant.* p. 551.

Puncturella noachina, *B. C.* iii. p. 257, pl. vi. f. 2; v. p. 200, pl. lix. f. 1.

Hab. Korea, 30–54 fathoms; var. *princeps*, young. Type and variety: from Greenland and Wellington Channel southwards to Cape Cod, and from Spitzbergen to the Strait of Gibraltar; Sea of Okhotsk and North Japan: 4–250 fathoms. 'Lightning' Exped., 170 and 189 fathoms. 'Porcupine' Exped., 1869, 73–420 fathoms; 1870, 292–1095 fathoms.

Fossil. Miocene (?), Pliocene, and Quaternary or Post-tertiary formations, in Scandinavia, Great Britain, and Sicily; mostly in "glacial" deposits.

As usual in the case of tolerably common species like this, *P. noachina* has received several other names.

Attached to a living specimen of *P. noachina* from 420 fathoms in the first 'Porcupine' Expedition was a *Planorbulina* (one of the Foraminifera) of the same kind that has occurred in the Korean dredgings. Mr. H. B. Brady tells me that this *Planorbulina*

was common also in the 'Challenger' dredgings, but that he had not hitherto found any satisfactory description or figure of it.

Turbo sanguineus, *Linné*.

T. sanguineus, *L. S. N.* ed. xii. p. 1235.

Var. *pallida*. Smaller, yellowish white with a red apex or tip, and having the spiral striæ rather slighter and more numerous.

Hab. Korea, 2–4 fathoms; several specimens. Throughout the Mediterranean, from a few fathoms to 120.

Fossil. Newer Tertiaries of Nice and Southern Italy.

The colour of Mediterranean specimens varies from blood-red to yellowish-brown; but the apex is always red. Such specimens likewise differ in respect of the number and comparative stoutness of the spiral striæ.

The umbilicus is perforated in the young only. It is probable that Linné may have included *Trochus Adansoni*, and especially the variety *turbinoïdes*, in his description of *Turbo sanguineus*, by saying "umbilicus aliis perforatus, aliis nequaquam."

It is the *Turbo purpureus* of Risso and *T. coccineus* of Deshayes.

PTEROPODA.

Embolus rostralis, *Eydoux & Souleyet*.

Spirialis rostralis, *Eyd. & Soul. Rev. Zool.* 1840, p. 236; *Soul. Voy. Bonite*, ii. p. 216, pl. xiii. f. 1–10.

Hab. Korea. Oceanic and gregarious in all southern latitudes.

Weinkauff mistook this for the *Spirialis Jeffreysi* of Forbes and Hanley, which belongs to a different genus.

Of the above named fourteen species, six (viz. *Anomia ephippium*, *Pecten similis*, *Lepton sulcatulum*, *Axinus flexuosus*, *Panopea plicata*, and *Turbo sanguineus*) are here noticed for the first time as living in the North Pacific as well as in the North Atlantic; *Nucinella ovalis* and *Kellia pumila*, which had been regarded as extinct, the former not only specifically but generically, are now recorded as recent: the other six species (viz. *Terebratula caput-serpentis*, *Crenella decussata*, *Lasæa rubra*, *Saxicava rugosa*, *Puncturella noachina*, and *Embolus rostralis*) were already known to inhabit both oceans. No less than nine out of these fourteen species are Coralline-Crag fossils: they are *Terebratula caput-serpentis*, *Anomia ephippium*, *Pecten similis*, *Nucinella ovalis*, *Lasæa rubra*, *Kellia pumila*, *Axinus flexuosus*, *Panopea plicata*, and *Saxicava rugosa*.

On the Asteroidea and Echinoidea of the Korean Seas.

By W. Percy Sladen, F.L.S., F.G.S.

[Read June 6, 1878.]

(Plate VIII.)

The Echinoderms collected by Capt. St. John whilst surveying in the Straits of the Korea and neighbouring Japanese waters, were intrusted by Dr. J. Gwyn Jeffreys and Dr. Günther to Prof. P. Martin Duncan, to whose kindness in placing the material in my hands I owe the pleasure of presenting the following communication upon the small but very interesting series of Asteroidea and Echinoidea. It is only justice due to Capt. St. John to remark that the value of the present collection is enhanced by his very careful registration of the exact position and depth at which the specimens were taken; whilst the importance of the Echinoderms themselves is increased by the fact that many of them belong to forms hitherto little known or imperfectly described; in addition to which several are represented by small and premature growth-stages, which enable us to fill in phases in the life-history of the species to which they belong. The association of several of the species will also be found full of particular interest.

Holding the opinion that the duty of a naturalist is not completed by the simple determination of mere lists of species from a given locality, but rather that it lies in pointing out what variations are undergone by known "forms" from the general type in order to attest the results of the conditions of the special habitat, it has been the aim of the author to indicate as far as he was able the particular modifications presented in the cases under notice, or at least to denote the grounds on which the determinations rest.

ASTEROIDEA.

Astropecten formosus, sp. nov. Pl. VIII. figs. 1, 2, 3, 4.

Coll. St. John: Korea, 36 and 54 fathoms (young); W. Coast of Nipon, 60 fathoms.

Disk large, rays short, arm-angles widely rounded; the greater and lesser radii of the largest specimen measure respectively 14·5 millims. and 5·2 millims., or in the proportion of $2\frac{3}{4}:1$ approximately. The foot-papillæ, which are all cylindrical and taper towards the tip, form two series: the inner one, which spreads

out into a comb overhanging the ambulacral furrow, is composed of three papillæ, the middle one being longer than the others; the outer series, which radiates towards the ventral plates, consists in the middle of the arm of three papillæ, whilst along the inner fourth of the furrow there are four or five, these being arranged two and two, or two and three together, one pair opposed to the inner series, the others placed more external and nearer together. On the innermost plates of the ray this external series of foot-papillæ is further augmented by two or three additional spinelets, and which form an almost imperceptible transition into the scuticles of the ventral plates. The ventral marginal plates bear three spines—the uppermost, or that nearest the margin, being the smallest; the second is large, compressed and acuminate, twice the size of the marginal spine, and is succeeded by another almost as large. The spines are arranged obliquely across the plate, except in the arm-angle, where they form a straight series along with two or three additional spinelets which lie between them and the furrow. The main spines of these inmost plates of the arm-angle are also somewhat smaller than their successors. The rest of the ventral plate is covered with numerous small compressed and finely acuminate scuticles, standing erect and fairly well spaced, which present quite a different appearance to the flat, closely-packed, spatulate scales which so frequently clothe the under surface of *Astropecten*. The furrows between the plates are wide, having the margins set with fine setæform spinules, very different from the armature of the plate just described. The upper marginal plates, which are broader than long, number about sixteen on each side, exclusive of the tip. They are closely papillate; and the spine-like papillæ are cylindrical, with radiate tips more or less expanded and quite clavate. There are about five rows of these spinelets upon a plate, exclusive of the marginal setæform series, the middle ranges being larger than the rest; whilst the setæform spinelets which fringe the furrows are much longer and more delicate, and present in a more marked degree the clavate character of the tip.

The paxillary area is, at the middle of the ray, a little broader than the marginal plate (though not twice as broad); and the paxillæ are large and very distinctly stellate, 5–6-radial, with a ray springing from the centre as well, though sometimes this is wanting. The madreporiform body is situated close to the marginal plates.

Two very young *Astropectens*, measuring respectively 10·5 millims. and 8 millims. in their greatest diameters, seem to belong to this species. The relative characters of the disk and rays, the arrangement of the foot-papillæ, the armature of the ventro-marginal plates, and the paxillæ of the dorsal surface present only such differences as might be expected in the premature conditions of the *Astropecten* above described. The inner row of foot-papillæ consists of three spinules as in the adult form; but in the outer series there are only two on the outer portion of the furrow, and three on the inner; their arrangement, however, being such as to leave little doubt, when comparison is made with the different portions of the furrow in the largest specimen, that they belong to one and the same speeies. On the marginal plates of the smaller specimen there is only one spine; but on the larger there seems indications here and there of the future development, out of the plate armature, of the larger companion spines. The paxillæ are large and much simpler than in the adult, having fewer radii.

Although these juveniles were dredged on different occasions—one being taken off the Korea at the depth of 54 fathoms, and the other off W. coast of Niphon, 60 fathoms—they both agree in the singular circumstance of having gorged a small bivalve! and in each case apparently of the same species. In the larger of the two young starfish the distention of the test and the position of the shell lead to the supposition that the diminutive *gourmand* had fallen a martyr to the indulgence of its appetite!

This *Astropecten* bears some resemblance to certain examples of the northern form known as *Astr. Mülleri*, M. & T.; regarding that, however, as an extreme variation of *A. irregularis*, the differences presented by the Asteroids at present under consideration are such as to justify the opinion that they should be classed (provisionally at any rate) as distinct from that species. It would not, however, be surprising to find, from the examination of a larger supply of material from this and other localities than is at present available, that the above specific determination would require to be included within the *extended* diagnosis of the type of *A. irregularis*, although the distribution as at present known of the varietal forms of that species (e. g. *A. Mülleri*, *A. echinulatus*, etc.) would hardly lead to such a supposition.

Astropecten japonicus, *Müller & Troschel.*

1842. Astropecten japonicus, *Müller & Troschel, System der Asteriden,* p. 73.

Coll. St. John: Korean Straits, 9 fathoms.

The arms are moderately long and narrow; R=11·25 millims., $r=4$ millims. The foot-papillæ, arranged in wedge-shaped groups of five, are long, fine, and cylindrical. The first spinelet, which forms the apex of the wedge, stands by itself, projecting inward upon the furrow, is thicker than the rest and arched upwards at its base; the others stand external to this, two and two together, the outermost pair being rather longer than the inner pair; whilst on the inmost portion of the furrow the outer series of papillæ are augmented by one or two additional spinelets. The adambulacral plates which bear the foot-papillæ appear very much depressed, in consequence of the gibbous character of the ventro-marginal plates—a feature which is very striking when compared, for instance, with specimens of *Astr. formosus*, mihi, of nearly equal size.

The upper marginal plates are broader than long, and covered closely with short stout granulose spinules of clavate form, and on the outer half of the arm carry on their outer margin a small conical spinelet. In the specimen under notice the nine outer, out of thirteen marginal plates, are thus armed.

The ventro-marginal plates project more outwardly than the upper marginal plates, and bear one large, compressed, lanceolate spine at the margin, which is generally followed by two smaller spines placed side by side, not half its length, and very much finer and more cylindrical. The rest of the spinulation consists of small, short, isolated, cylindrical spinelets. In the present example these have been very much abraded; and little further detail can be made out.

The dorsal area or paxillary field is, in the middle of the arm, very little, if any, broader than the marginal plate. The paxillæ are large and closely crowded—so much so that the radii (of which there are 8–9 and very robust) of a paxilla are directed upward, instead of at right angles to their pedicle; and this gives to the paxillary area a granulate rather than a stellate appearance to the naked eye, and without any indication of regular arrangement.

Dr. Lütken remarks* on never having seen an *Astr. japonicus*

* 'Videnskabelige Meddelelser' for 1864, p. 127.

with the spines upon the dorsal marginal plates. On the specimen under consideration these are so small that they might easily be passed over without notice,—whilst, further, it is a character of such usual variability that I am fully prepared to believe in the existence of examples in which they are wanting altogether, their rudimentary state on the present specimen quite leading to that idea. A seemingly parallel instance may be pointed to in the case of *Astr. euryacanthus*, Ltk.*, in the premature stages of which small spines are present on the outer margin of the dorsal marginal plates towards the ends of the arms, but no trace of them remains in the adult†.

Our knowledge of this species at present is very scanty; and it may not be beyond the range of probability that a more extensive series of specimens will require the modification of our current ideas of the form altogether, and possibly even its amalgamation with such a species as *A. scoparius*, when more is definitely known about the premature stages of these *Astropectens*.

ASTROPECTEN POLYACANTHUS (of *A. armatus*-type), *M. & T.*

1842. Astropecten polyacanthus, *Müller & Troschel, System der Asteriden*, p. 69, taf. v. fig. 3.

— Astropecten hystrix (*Val. MS.*), *M. & T. ibid.* p. 70.

— Astropecten armatus, *Müller & Troschel, ibid.* p. 71.

1843. Astropecten vappa, *Müller & Troschel, Wiegm. Archiv f. Naturgesch.* Jahrg. 9, p. 119.

1864. Astropecten armatus, *Lütken, Vidensk. Meddelelser* for 1864, p. 132.

1865. Astropecten armatus, *v. Martens, Ueb. Ostasiat. Echin., Wiegm. Archiv*, Jahrg. 31, p. 352.

1876. Astropecten polyacanthus, *Perrier, Stell. du Mus., Arch. de Zoologie gén. et expér.* t. v. p. 275.

Coll. St. John: Yedo Bay.

So far back as 1864, Dr. Lütken ‡ raised the question as to the validity of the separation of *A. armatus*, M. & T., from Japan, and *A. vappa*, M. & T., from Australia, as species distinct from the typical form of *A. polyacanthus* from the Red Sea, asserting his inability to detect in the material he had examined any characters of specific value to warrant such a division. M. Perrier, after

* Vidensk. Meddel. 1871, p. 232.

† Compare with this Lütken's remarks on a specimen of *Astr. aster* wanting the spines (in Vidensk. Meddel. 1864, p. 130).

‡ "Kritiske Bemærkninger om forskjellige Söstjerner," Vidensk. Meddel. 1864, p. 132.

studying the large collections in Paris, concurs in these views, and maintains the consolidation of the above-mentioned forms, including also *A. hystrix* (Val.), M. & T.*

M. Perrier further expresses his opinion that the differences upon which the separation has stood are nothing more than conditions of age and locality—the series of specimens which the French *savant* has had the opportunity of examining being procured from stations as widely distant as Zanzibar, Muscat, Ceylon, Hong-Kong, Fiji Islands, Port Jackson and several other localities in Australia, thus indicating a very extensive distribution of the *A. polyacanthus* type.

Although the present specimen is in a somewhat weathered condition, it can unmistakably be assigned to the varietal group formerly described under the name of *A. armatus*, M. & T. In each ray the three marginal plates which succeed to the innermost in the arm-angle are destitute of tubercles and dorsal marginal spines. This character is regular, and accords with the typical description given in the 'System der Asteriden.' Lütken (Vidensk. Medd., 1864, p. 132) chronicles the occurrence of considerable irregularity and variation in the number of these spineless plates in different rays of the same individual, and cites examples from Hong-Kong having only one, or two, or even none of the undeveloped spineless plates on different rays of the same specimen. This starfish measures $R=35$ millims., $r=9{\cdot}6$ millims.

Without calling in question the accuracy of M. Perrier's determination, the occurrence of such instances as this of a form presenting strongly marked variations at different stations within the area of its distribution, urges upon naturalists the necessity of exercising extreme caution against being led away by a tendency to group too comprehensively the forms which may be included within a large and widely distributed genus; for however seriously the multiplication of frivolous "species" may embarrass a classification, the wholesale grouping, or, in other words, the unbounded extension of the limits of specific character, is productive of much more injurious results, in that it curtails the precision of definition, and, whilst ignoring environment as a factor, divests nomenclature of one of its highest and most important qualities.

* "Stellérides du Museum," Archives de Zoologie expérimentale et générale (Lacaze-Duthiers), tome v. 1876, p. 275.

From the fact that forms are separated by much smaller and less striking differences in an extensive genus than in one of more limited scope, "species" in the larger group have often not such clearly marked or conspicuous characters as those which are presented by "varieties" in a less comprehensive genus. It follows that the judgment should be very cautiously exercised when tempted to embrace within a single species all the strongly marked distributional extremes of any widely-spread type, however closely their connexion may seem to be preserved through intermediate forms; for in many cases these gradations are nothing more or less than the links which indicate to us the development of "species," and are, in short, the stages with which generally we are unacquainted, owing either to the imperfection of knowledge, or more frequently by reason of their destruction through the hostility of unfavourable conditions.

Taking into consideration the advance which knowledge is continually making by means of the addition of new material from hitherto unexplored fields, the process of too comprehensive grouping would ultimately result in the formation of series which, from their very unwieldiness, would require arbitrary division for the mere purposes of classification and comprehension, if the ordinary natural distinctions be ignored. Of course it will be acknowledged that "species" are but arbitrary divisions after all, and that a *nomen triviale* serves but to register the state of information and our opinions upon certain forms of life; but since under such an aspect the organisms themselves stand as the outcome of adaptation and the conditions of existence, the latter factor being thus synonymous with *habitat* or geographical position, taken in its widest sense, it would evidently be a disadvantage to science to lose the record of the influence which has been exerted, and to sacrifice so simple an indication of the relative position of a modified type within the area of its general occurrence.

STELLASTER BELCHERI, *Gray*.

1847. Stellaster Belcheri, *Gray, Proc. Zool. Soc.* 1847, p. 76; *et Synopsis of Starf. Brit. Mus.* (1866), p. 7, t. vii. fig. 1.

1866. Goniaster (Stellaster) Belcheri, *von Martens, Ueb. Ostasiat. Echin., Wiegm. Archiv,* Jahrg. 32, p. 86.

1871. Goniaster (Stellaster) Belcheri, *Lütken, Vidensk. Meddelelser* for 1871, p. 247, tab. v. fig. 3.

1876. Pentagonaster (Stellaster) Belcheri, *Perrier, Stellérides du Museum, Arch. de Zool. expér. et gén.* t. v. p. 42.

Coll. St. John: Korean Straits, 50 fathoms.

In the type specimen figured and described by Dr. Gray, a group of two or three small tubercles is situated upon the disk in each radial area at about the same distance from the centre as the madreporiform body, whilst further outward, at the base of the arm, stands a single isolated tubercle, likewise in the median line of the ray.

In an example of *S. Belcheri* from Australia, which Dr. Lütken has described, this latter tubercle is wanting; and from the circumstance of the specimen being much smaller than that of Gray's (measuring only $r=8$ millims., $R=25$ millims.), Lütken has been led to regard the presence of this isolated tubercle at the base of the rays as merely a dependence on age and growth.

The present specimen is smaller than either of the above, and is interesting from the fact that the only tubercles which it possesses are a single one in each radial field. Each of these occupies the middle of a plate which is situated rather further than the madreporiform body from the centre of the disk, and is surrounded by several small granules markedly larger than those which cover the plates generally. The disk is moderately convex, the radial areas gibbous, and the interradial ones depressed. The semidiameters of the disk and rays measure 7 millims. and 19 millims. respectively.

The inner row of foot-papillæ form a compact comb on each interambulacral plate, arching upward over the furrow and having in each group 5–6 papillæ, the ad- and aboral being smaller than the others. The outer series consists of a single small, short, stout papilla placed opposite to the middle of the inner row, and having two or three papillate granules on each side, sometimes in line and sometimes behind it, the whole forming a more or less regular line parallel with the inner series. Occasionally a few additional granules form an irregular reduplication of this series, whilst upon the inner portion of the furrow the granules which stand near to the main single papilla gradually increase in size, the distinction between them becoming almost imperceptible. There are but few *pedicellariæ valvulatæ* on the dorsal surface, and none on the marginal plates. The marginal spines are compressed, not tapering towards the tip, which is rounded. Upon the two outer thirds of the arm there is only a single plate in the dorsal

area between the marginal plates, the last two or three of which meet in part of their length, and thus disconnect the median series.

CRIBRELLA DENSISPINA, sp. nov. Pl. VIII. figs. 5, 6, 7, 8, 9.

Coll. St. John: Korean Straits, W. coast of Niphon, 40 fathoms.

Arms rounded and very uniform in thickness throughout their length, tapering only slightly and very gradually towards the extremity, which is blunt and well rounded. Arms slightly flattened at the base, and quite continuous with the disk, being separated by no interradial depression; arm-angles well rounded. The ossicles of the rays and disk are covered very densely with small closely-crowded spinelets, so closely packed as to suggest to the naked eye the granulate appearance of *Linckia*. The spinelets are built-up of multiradiate laminæ, and by expansion at the tip assume a clavate form. The intermedial pore-arms are very small, quite disconnected and enclosed; they are frequently furnished with one papilla only; but two or occasionally even three occur.

The madreporiform body is nearer to the centre than the margin of the disk; and the septa, which radiate in straight lines from its centre, are closely studded with spinelets similar to those of the disk and rays.

The foot-papillæ are more robust than the spinelets of the dorsal or lateral portions of the ray, and are placed in oblique pairs upon the adambulacral plates. The inmost pair, or that nearest the furrow, are longer and much stouter than the others, and are succeeded by four or five similarly oblique pairs of smaller spinelets, following in series and gradually diminishing in size and thickness until they merge imperceptibly into the densely packed spinulation of the ventro-lateral plates.

The specimen measures R=25 millims., r=5 millims.; breadth of a ray midway between the tip and disk, 4 millims.

ASTERACANTHION RUBENS (*Linné*), var. MIGRATUM, *mihi*.

Coll. St. John: Korean Straits.

Two small specimens, their greatest radius measuring 16 millims. and 12 millims. respectively. Although only in a young and premature stage of growth, I feel little hesitancy in assigning these starfish to the above widely spread species.

The ambulacral papillæ are short, moderately stout, and cylindrical, and arranged two and one alternately upon the interam-

bulacral plates, with more or less regularity according to the individual, sometimes the odd spines being few and far between. These are succeeded by the ventro-lateral spines in oblique rows of two (or three in the middle portion of the arm), and are stout, moderately long, and slightly tapering towards the tip; then follows the broad side-area, bounded by the lateral spines, which are similar in size and character to the last mentioned, and, standing one to a plate, are well spaced and form a straight marginal series. These spines are surrounded at the base by a thin circlet of small *pedicellariæ forcipiformes* *; and the ventro-lateral series have also a few on their upperside. The spines of the dorsal surface are small, tapering towards the tip, and pointed; they are widely spaced and have a few *pedicellariæ forcipiformes* at their base, but no wreath (and in some cases only two or three even), whilst the interspace between the spines is very thickly strewn with numerous large *pedicellariæ forficiformes*.

The large size and great number of these latter pedicellariæ, as well as the isolated character of the marginal spines, without even a trace of any undeveloped companion such as is frequently to be found in young *A. rubens* of typical form at the same age, the general absence of all embryonic secondary spines on the intercalary pieces, either of the dorsal surface or the sides, and, in

* In 1866, Dr. W. B. Herapath published a memoir "On the Pedicellariæ of the Echinodermata" (Quart. Journ. Microscop. Science, vol. v. pp. 175–184), in which he described the structure of these organs as presented in the Asteriadæ, at the same time assigning very characteristic technical designations to the different forms. This paper, unfortunately, seems to have been overlooked by subsequent writers, and also by M. Perrier, who in 1869 brought out his careful and very excellent 'Recherches sur les Pédicellaires et les Ambulacres des Astéries et des Oursins.'

Apart, however, from Dr. Herapath's obvious claim to priority, certain of the names employed by the French *savant* can only be regarded as colloquial terms which would require to be replaced by a more strictly scientific nomenclature before they could become the general property of the naturalists of other countries. It is therefore with particular pleasure that attention is called to the above mentioned earlier paper, as it supplied the want in the direction indicated.

According to Dr. Herapath's terminology, the *pedicellariæ forcipiformes*, or "scissor-shaped," are equivalent to the "pédicellaires croisés" of M. Perrier; and the *pedicellariæ forficiformes*, or "shears-shaped," to the "pédicellaires droits" of the French author. The terms being synonymous with the "major" and "minor," the "large" and the "small," as applied to pedicellariæ by some American and English naturalists.

fact, the *tout ensemble* of the spinulation, dispose me, after careful study of this limited material, to regard the starfish as presenting a well-marked locational variety of the *A. rubens* type. And although these structural modifications are not such as would command more special recognition, the divergence seems one which is well worthy of record in a morphological point of view.

ECHINOIDEA.

STRONGYLOCENTROTUS INTERMEDIUS (*Barnes*), *A. Agassiz.*

1863. Psammechinus intermedius, *Barnes, in A. Agassiz, Proc. Acad. N. S. Philadel.* p. 357.

1866. Boletia radiata, *von Martens, Ostasiat. Echin., Wiegm. Archiv,* Jahrg. 32, p. 136.

1872. Strongylocentrotus intermedius, *A. Agassiz, Rev. Echini, Ill. Cat. M. C. Z.* p. 164.

Toxopneustes grandiporus, *Lütken* (*MS. Copenhagen Mus.*), *fide A. Agassiz.*

Coll. St. John: lat. 34° 8′ N., long. 126° 24′ E., Korean Straits, 24 fathoms.

Owing to its dense clothing of short moderately uniform spines, this Echinoid bears a great resemblance in facies to *Sphærechinus.* The resemblance, however, is merely superficial, as neither the tubercles nor the spines are equal-sized, nor are the former closely packed upon the plates or arranged in strictly horizontal rows; the gill-slits are very slight, being little, if at all, more deeply indented than generally in *Strongylocentrotus.* In none of the above-mentioned details, which are regarded as stable generic characters in *Sphærechinus*, does the present sea-urchin agree; and although it resembles that genus in possessing only four pairs of pores to each arc, their mode of arrangement does not differ essentially from that of *Strongylocentrotus.*

The poriferous zones are nearly as broad as the median ambulacral area, which at the ambitus bears four vertical ranges of tubercles—the outer ones, which stand next to the poriferous zones, being much larger than the inner series. On the interambulacral plates there are three primary tubercles, the middle one longest; and this alone remains prominent up to the apical disk, whilst the companion tubercles diminish very rapidly on the abactinal surface, being wanting altogether or represented only by small miliaries on the uppermost plates. There are also two or three large secondaries and a moderate sprinkling of miliaries

upon the plates, but which diminish both in size and number on the upper portion of the abactinal surface; two of the secondaries are placed on the aboral margin of the plate, and stand above the interspaces between the primary tubercles. There are also two or three small tubercles between the arcs in the poriferous zones, the one which stands under the upper pore of each ambulacral plate (*i. e.* the second pore of an arc) being nearly as large as a primary tubercle; and its series forms a prominent vertical row. The genital plates are comparatively small, with the exception of the madreporite, and the oculars large, two of them entering the anal circle; both the ocular and ovarial orifices are conspicuous.

The actinostome is small, the indentations well marked but not deep, and the buccal membrane furnished with small elongate calcareous plates.

The colour of the test is light purple or greenish, having the interradii frequently of a darker tint; and that of the spines dark olive tipped with purple. In one small specimen the spines of the ambulacra are greyish white tipped with violet. The specimens dredged by Capt. St. John accord closely with the description given by Von Martens of *Boletia radiata*, which Mr. Alex. Agassiz indicates, from personal knowledge, to be synonymous with Barnes's earlier determination of *Psammechinus intermedius*. Hence the present reference of the Echini under consideration.

ECHINOMETRA LUCUNTER (*Leske*), *Blainville.*

Coll. St. John: Hatzura, Japan.

Only one small premature specimen, which seems to vary from the ordinary Pacific form in its shorter and stouter spines, and prominent and somewhat exposed apical disk. *E. lucunter*, however, is such a highly variable form, and the changes which take place during growth are so great in all the members of the genus, that the "suggestions" presented by the example under notice do not appear to warrant any special importance being placed upon them. The colour of the spines is light green shading into light violet, and tipped with grey, and having the milled rim white or grey also. Pores arranged in arcs of four.

TEMNOPLEURUS HARDWICKII (*Gray*), *A. Agassiz.*

1855. Toreumatica Hardwickii, *Gray, Proc. Zool. Soc.* p. 39.

1863. Microcyphus elegans, *A. Agassiz, Proc. Acad. N. S. Philad.* p. 357.

1863. Temnotrema sculpta, *A. Agassiz, Proc. Acad. N. S. Philad.* p. 358.

1866. Temnopleurus japonicus, *von Martens, Wiegm. Archiv,* Jahrg. 32, p. 133.

1872. Temnopleurus Hardwickii, *A. Agassiz, Rev. Echini,* pp. 166 & 460.

Coll. St. John: lat. 38° 28′ N., long. 141° 25′ E., Sendai Bay, 9 fathoms; lat. 32° 49′ N., long. 128° 54′ E., Korea (young).

In this *Temnopleurus* the sutural pits are wanting altogether on the actinal surface, whilst above the ambitus they are deep and bevelled in the median line of the interambulacral areas, but only small adjoining the poriferous zone; the sutural pits of the ambulacral areas are similar to those of the interradia, though smaller; and these broad, connected, triangular excavations give quite a naked appearance to the median line of the areas. The coronal plates carry only one large primary tubercle, which in the interambulacral areas is placed near the middle of the plate—the series forming two vertical prominent lines, which extend from the apical pole to the actinostome. The spines which are attached to these primaries are conspicuous from all the rest, both by their greater length and by their coloration, which at the base is very dark brown or purple, with the rest of the shaft pink. On either side of the interambulacral primary tubercles there is in general (except towards the apical disk) one large secondary tubercle, the remainder of the plate carrying numerous robust miliaries. In the ambulacral areas the primary tubercle is placed near the outer margin of the plate, and is accompanied by one or, near the ambitus, sometimes two secondaries and several miliaries. The anal area is small; and the genital plates are well tuberculated. The actinostome is also small in comparison with other species.

The following measurements will show the proportions:—

	A. millim.	B. millim.
Diameter..................	24	27·25
Height	12	13·5
Actinostome	8	8·1

Two young specimens of this species were also obtained, and accord very closely with Mr. A. Agassiz's excellent figures of the growth stages of this *Temnopleurus*. They were dredged in

lat. 32° 49′ N., long. 128° 54′ E., and measure respectively 7 millims. and 11·2 millims. in diameter.

Temnopleurus Reynaudi, *Agassiz* (juv.).

1846. Temnopleurus Reynaudi, *Agassiz, Cat. rais., Ann. Sc. Nat.* vi. p. 360.

1855. Toreumatica Reevesii, *Gray, Proc. Zool. Soc.* p. 39.

—— ? Toreumatica granulosa, *id., ibid.*

1863. Toreumatica concava, *A. Agassiz, Proc. Acad. N. S. Philadel.* p. 358 (*non Gray*).

1872. Temnopleurus Reynaudi, *A. Agassiz, Rev. Echini*, p. 166.

Coll. St. John: lat. 33° 14′ N., long. 182° 55′ E., Korea, 40 fathoms.

Very little was definitely known respecting the premature phases of *Temnopleurus* prior to the careful and characteristic drawings which Mr. Alex. Agassiz has given of this and the preceding species. The present specimens, of a diameter of 9 millims., are distinguishable from young *T. Hardwickii* of about the same size by their thinner, more compressed, and subconoid test, which is of a light ashy-grey colour, rayed with pale violet in the interambulacral areas. The apical disk is conspicuous, and the primary anal plate very large and characteristic; the ocular plates are large, with their outer margin tridentiform, and having at the base adjoining the genital plates a lozenge-shaped pit; one ocular enters the anal circle. The interambulacral sutural excavations extend up to the primary tubercle, which has the appearance of standing at the apex of a triangular depression occupying the entire adoral margin of the plate; the pits are larger and more clearly defined on the actinal than upon the abactinal surface, and those of the median ambulacral area bear on their adoral margin a very large sphæridia, the series of these, which number six or seven, extending nearly up to the ambitus. There are but very few miliaries upon a plate; and the two or three which occupy the upper portion still bear traces of fine radial connexions with the primary tubercle. The secondary tubercles, of which, at the ambitus, there is one on either side of the primary, are comparatively small.

In young *T. Hardwickii* of the same size the tuberculation of the plates is distinct and more numerous, and the sutural pits, though deep, are much more limited.

TEMNOPLEURUS TOREUMATICUS (*Klein*), *Agassiz* (?) (juv.). Pl. VIII. figs. 10, 11, 12, 13.

1734. Cidaris toreumatica, *Klein, Nat. Dispos. Echin.* p. 64.
1788. Echinus toreumaticus, *Gmelin, Linn. Syst. Nat.* 3180.
1816. Echinus sculptus, *Lamarck, Ann. sans Vert.* p. 47.
1841. Temnopleurus toreumaticus, *Agassiz, Monog. Scutelles,* p. 7; *et in Valentin, Anat. du gen. Echin.* p. vii.
1846. Temnopleurus bothryoides, *Agassiz, Cat. Rais., Ann. Sc. Nat.* vi. p. 360 (pars).
1863. Temnopleurus Reevesii, *Agassiz, Bull. Mus. Comp. Zool. Harvard,* i. p. 23 *non* (*Gray*).
1872. Temnopleurus toreumaticus, *A. Agassiz, Revision of Echini,* p. 166.

Coll. St. John: lat. 34° 8′ N., long. 126° 24′ E., Korea, 24 fathoms.

A small specimen measuring 9·5 millims. in diameter, which differs entirely from the preceding young *Temnopleuri*, I refer, although not without hesitation, to the above species. The test is stout; and the primary tubercles are large and very prominent, with the sutural pits extensive and sharply defined. The well-developed secondaries and miliaries which fill the plates, form oblique lines thereon, continuous with similar lines on the companion plate, the miliaries of the upper portion of one plate following the same trend as the lower and principal range of tubercles on the accompanying plate. This feature, combined with the band-like character of the portion of the interambulacral plates which lies between the sutural cavities, is very suggestive of the arrangement in *Temnechinus*. The genital plates are comparatively large; and the anal area is surrounded by a prominent and close ring of robust secondary tubercles. Compared with young *T. Hardwickii*, the Echinoid under notice is readily distinguished from specimens of similar or even greater size by the prominent character of the tuberculation and the regularity of the special arrangement which this displays.

If the view be correct that the present premature specimen is the young of *T. toreumaticus*, the characters which it presents are such as point to an interesting phylogenetic connexion of *Temnopleurus* with *Temnechinus*; whilst it much more nearly resembles the fossil forms of that genus than the seemingly aberrant species *Temnechinus maculatus*, A. Agassiz.

Salmacis sulcata, *Agassiz.*

1846. Salmacis sulcatus, *Agassiz, Cat. Rais., Ann. Sc. Nat.* vi. p. 359.

—— Salmacis virgulatus, *id., ibid.*

1850. Melobosis mirabilis, *Girard, Proc. Boston Soc. Nat. Hist.* iii. p. 365.

1866. Salmacis conica, *von Martens, Ostasiat. Echin., Wiegm. Archiv,* Jahrg. 32, p. 159.

—— Diploporus pyramidata, *Troschel, Mus. Berolin.* (fide *v. Martens*).

1866. Salmacis pyramidata, *v. Martens, Wiegm. Archiv,* Jg. 32, p. 159 (pars).

1872. Salmacis sulcata, *A. Agassiz, Rev. Echin., Ill. Cat. M. C. Z. Harvard,* p. 156.

Coll. St. John: lat. 34° 8′ N., long. 126° 24′ E., Korean Straits, 24 fathoms.

Test subconoid and somewhat depressed, having small sharp triangular pores in the median areas and at the junction of the interambulacra with the poriferous zones. Ambulacral pores arranged in triple arcs, which have the appearance of forming two vertical rows, two pore-pairs standing on the inner series to one on the outer, in regular alternation—the intermediate space between these single pore-pairs being occupied by a small secondary tubercle which isolates them from one another. Coronal plates narrow, the inner third of each being naked. The interambulacral plates at the ambitus bear a horizontal row of three small tubercles, of which the middle one is the largest, and forms a vertical series extending from the apical pole to the actinostome; the series adjoining the poriferous zone disminishes very rapidly in size on the abactinal surface, becoming merely miliaries which hadly reach the apex; whilst the inner series extends only half the distance from the ambitus to the apical disk. Above these tubercles, on the upper margin of each plate, runs a horizontal row of well-spaced miliaries. The ambulacral plates carry one large tubercle closely adjoining the poriferous zone; and this at the ambitus is accompanied by another rather smaller tubercle in horizontal line, but which does not extend in vertical series to within one third of the distance of the apical disk. In addition to these primary tubercles, there are two or three miliaries on the upper margin of the plate, of which the one standing midway over the interspace between the two primaries is almost as large as a secondary tubercle, and extends in series much further towards the apical disk than the small inner primary.

The apical system is moderately large, with the anal margin closely tuberculated; the genital apertures are very large and round, and the plate bearing the madreporiform body much larger than the others; the ocular plates are stout and carry numerous tubercles, one being placed on each side of the aperture. Three specimens furnished the following measurements:—

	A. millim.	B. millim.	C. millim.
Diameter	17	14	14
Height	11·75	8·3	9·1
Actinostome	7	6	6

ECHINANTHUS TESTUDINARIUS, *Gray*.

1851. Echinanthus testudinarius, *Gray, Proc. Zool. Soc. Lond.* p. 35; *et Cat. Echinida* (1855), p. 6, pl. i. fig. 1.

1851. Echinanthus australasiæ, *Gray, Proc. Zool. Soc. Lond.* p. 34, *et Cat. Echinida* (1855), p. 5, pl. i. fig. 2.

1854. Clypeaster tumidulus, *Müller, Bau d. Echin.* p. 90.

1866. Clypeaster testudinarius, *v. Martens, Wiegm. Archiv,* Jahrg. 32, i. p. 170.

1870. Clypeaster speciosus, *Verrill, Silliman's Journ.* p. 95.

Coll. St. John: lat. 33° 14′ N., long. 128° 55′ E., west coast of Nipon, Korean Straits, 40 fathoms.

ECHINANTHUS TESTUDINARIUS, *Gray*.

This Clypeastroid is distinguished by the form and height of test, with its deeply impressed and gradually sloping actinal surface and large actinostome; whilst the shape of the ambulacral petals, the thickened margins of the test, and its small and widely spaced tubercles are further characteristic of the species.

The superficial resemblances which exist between certain forms of *E. testudinarius* and *Clypeaster rotundus*, A. Ag., are remarkably close; the association, however, of their comparative differences with structural characters of considerable importance is very constant, and sufficient to warrant full recognition in specific determinations.

(CLYPEASTROID) —— sp. ? juv.

Coll. St. John: lat. 34° 8′ N., long. 126° 24′ E., Korea, 24 fathoms.

A small *Fibularia*-like Echinoid measuring 6·5 millims. in length, which is in all probability the young stage of a Clypeastroid; but to which special form it belongs it would obviously be very hazardous to determine from such limited material, in the

present state of our knowledge of the undeveloped stages of the species of that group. It is certainly different from any described *Fibularia*; but, from the characters which it presents, I prefer to regard it as a young and premature phase of growth, rather than as a new species of that very unsatisfactory genus.

ECHINOLAMPAS OVIFORMIS (*Gmel.*), *Gray*.

1788. Echinus oviformis, *Gmelin, Linn. Syst. Nat.* 3187.
1801. Nucleolites oviformis, *Lamarck, Anim. sans Vert.* p. 347.
1816. Clypeaster oviformis, *Lamarck, Anim. sans Vert.* p. 15.
1825. Echinolampas oviformis, *Gray, Ann. Phil.* x. p. 7, *et Cat. R. Echinida*, p. 35.
—— Echinolampas orientalis, *id. ibid.*

Coll. St. John: Korean Straits, W. coast of Nipon, lat. 33° 14′ N., long. 128° 55′ E., 40 fathoms.

The *Echinolampas* referred to the above species has a very elliptical and distinctly ovoid contour when seen from above; the test is high and fully arched; apex very eccentric anteriorly, and the mouth in a somewhat more central position on the actinal surface; bourrelets moderately developed. Ambulacral petals slightly petaloid, with poriferous zones unequally developed, the anterior zones of the antero-lateral pair and the posterior zones of the postero-lateral pair being little more than half the length of the companion zone of the petal; the inner pores are round, and the outer ones somewhat larger and elongated. Tuberculation moderately distant, and widely spaced in the neighbourhood of the actinostome. Apical disk small, and the genital pores not very wide apart.

The following measurements will serve for comparison:— Length 53 millims, breadth 44 millims., height 33 millims., anterior margin to centre of apical disk 17 millims.

ECHINOCARDIUM AUSTRALE, *Gray*.

1851. Echinocardium australe, *Gray, Ann. & Mag. Nat. Hist.* 2nd ser. vol. vii. p. 131, *et Cat. Echinida* (1855), p. 44, pl. iv. fig. 1.
1851. Echinocardium zealandicum, *Gray, Ann. & Mag. Nat. Hist.* 2nd ser. vol. vii. p. 131, *et Cat. Echinida* (1855), p. 44.
1863. Echinocardium Stimpsoni, *A. Agassiz, Proc. Acad. N. Sc. Philadel.* p. 360.
1869. Amphidetus novæ-zealandiæ (*Val.*), *Perrier, Rech. s. les Pédicell.* p. 176.

Coll. St. John: lat. 33° 10′ N., long. 129° 12′ E., Korea, 36 fathoms.

Three young specimens, two of them being very small. Compared with *E. caudatum*, the abactinal surface slopes at a much smaller angle from the apical pole, whilst the contour of the test, viewed from above, is much more rotund than in similar-sized specimens of the Atlantic species. The intrapetalous fasciole forms a wider triangle outwardly; and the anal and subanal fascioles are disconnected in examples measuring only 7·2 millims. in length; whilst in *E. cordatum* of even greater size they are unmistakably confluent. The apical disk is scarcely excentral; and the peristome, though only slightly so, is more anterior than in the young of *E. cordatum*. It will be further found, when comparison is made between the two species, that relatively the periproct occupies a very high position on the posterior end in the present form, and also that the zones of the posterior lateral ambulacra converge only very slightly as they approach the ambitus, whilst in *E. cordatum* they approximate rapidly.

An example of this species of the same size as the young *E. cordatum*, given by A. Agassiz in the 'Revision of the Echini,' has been figured for the purpose of comparison (*cf.* Pl. VIII. figs. 14, 15, 16, 17).

SCHIZASTER VENTRICOSUS, *Gray*.

1851. Schizaster ventricosus, *Gray*, *Ann. & Mag. Nat. Hist.* vol. vii. p. 133.

—— Schizaster Jukesii, *Gray*, *ibid.* p. 133.

1855. Schizaster (Nina) ventricosus, *Gray*, *Cat. Rec. Echinida, Brit. Mus.* p. 60, t. iv. fig. 2.

—— Schizaster (Nina) Jukesii, *Gray*, *ibid.* p. 61.

1872. Schizaster ventricosus, *A. Agassiz*, *Rev. Echin.* (*Ill. Cat. Mus. Comp. Zool.*), p. 158.

Coll. St. John: lat. 34° 13′ N., long. 136° 73′ E., 48 fathoms.

The collection contains one small specimen of this very fragile Echinoid, and measures only 14 millims. in length. Compared with *S. canaliferus*, the contour, when seen from above, is more elliptical, the test being much fuller and more rotund in the posterior portion, and having its greatest breadth across the hinder third; the apex is not so eccentric; and the present *Schizaster* is further characterized by the great height of the posterior portion of the test; a rapid slope to the actinal surface forms the truncate anal end, the upper part of which does not overhang the lower, the periproctal orifice being situated very high up on the area. The odd anterior ambulacrum is not so wide as in *S. cana-*

liferus; and the lateral keels which bound it are more strongly developed. The anterior lateral ambulacra are very broad, whilst the posterior petals are shorter, more pear-shaped, and have a concave curve outwardly.

Conclusion.

The following list will indicate the extremes, as at present known, of the geographical distribution of the species comprised in the above collection:—

ASTEROIDEA.

Astropecten formosus, mihi	Korea.
—— *japonicus*, M. & T.	Japan.
—— *polyacanthus*, M. & T.	Red Sea, Zanzibar, Australia, Fiji Islands, Japan.
Stellaster Belcheri, Gray	New Guinea, N. Australia.
Cribrella densispina, mihi.........	Korea.
Asteracanthion rubens, Linné......	Japan, N. Atlantic.

ECHINOIDEA.

Strongylocentrotus intermedius (Barn.), A. Ag.	Seghalion, Japan, Australia.
Echinometra lucunter (Leske), Bl..	Red Sea, Indian Ocean, Society Islands, Sandwich Islands, Japan.
Temnopleurus Hardwickii (Gray), A. Ag.	Japan, Unalaska (*Dall, Smithson. coll.*).
—— *Reynaudi*, Ag................	Ceylon, Malacca, N. China seas.
—— *toreumaticus* (Klein), Ag.	Persian Gulf, Siam, Philippine Islands, N. China seas.
Salmacis sulcata, Ag.	Red Sea, Indian Ocean, Australia, China.
Echinanthus testudinarius, Gray ..	Red Sea, Australia, Japan, Sandwich Islands, California.
Echinolampas oviformis (Gmel.), Gray.	Red Sea, Cape of Good Hope, Molucca.
Echinocardium australe, Gray	South Africa, New Zealand, Australia, China, S. Japan.
Schizaster ventricosus, Gray	Siam, Hongkong, Fiji Islands*.

An analysis of the above will show that, out of the six Asteroids, three are additions to the fauna of Japan, viz. *Astropecten formosus*, *Stellaster Belcheri*, and *Cribrella densispina*. Of these, *Stellaster Belcheri* has hitherto been known as inhabiting N. Australia and New Guinea only; *Astropecten formosus* may be regarded as

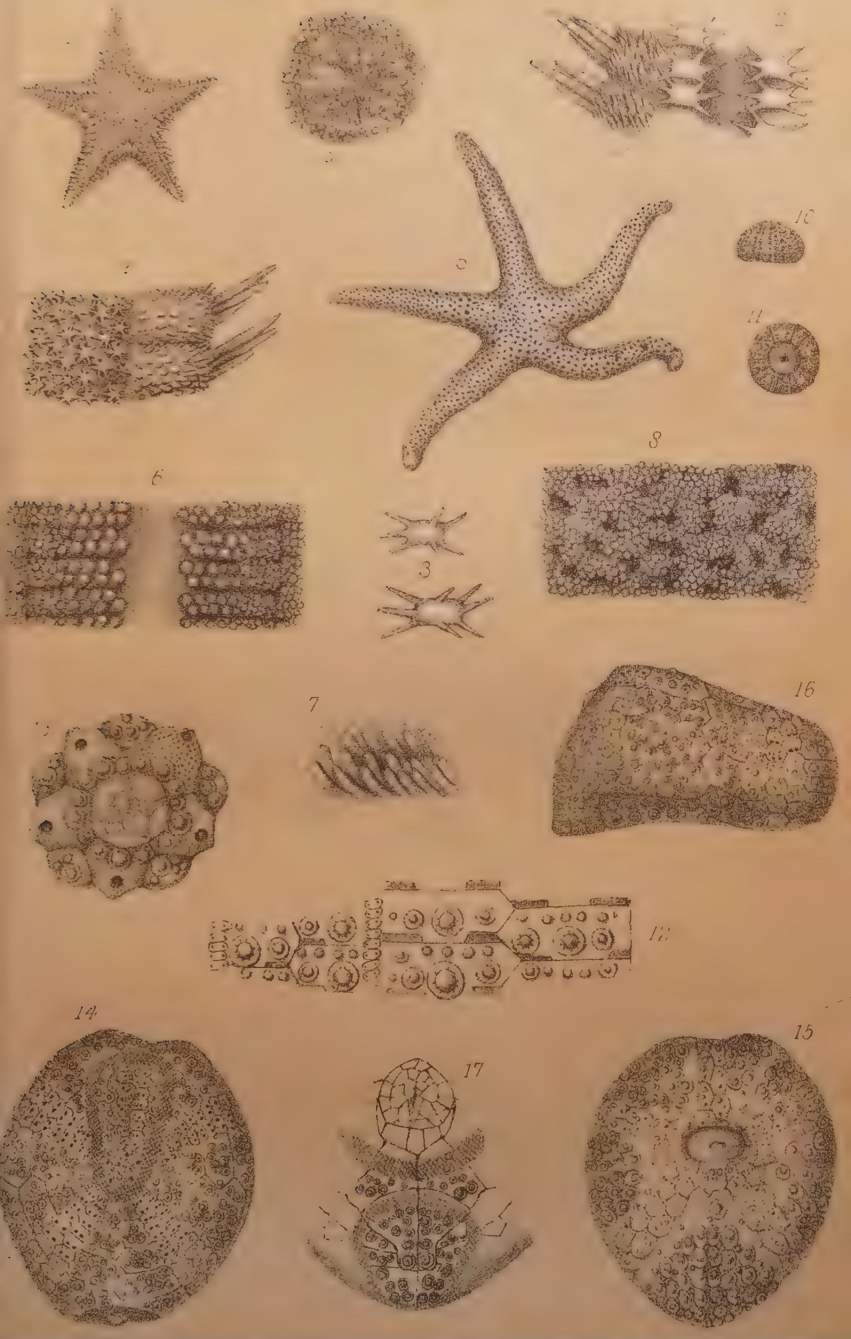
* In drawing up this list, I am indebted for a number of citations of collection to Mr. Alexander Agassiz's "Revision of the Echini," Ill. Cat. Mus. Comp Zool. Harvard, vii. 1872–74.

a representative form of the N.-Atlantic *A. irregularis* type; and *Cribrella densispina* I am disposed to consider an independent development from *C. sanguinolenta* of the N. Atlantic. Of the remaining Starfish, *Asteracanthion rubens* is the widely spread Atlantic and circumpolar Asteroid; *Astropecten japonicus* is confined to Japanese waters; and *Astr. polyacanthus* has a very extensive distribution, extending from the Red Sea on the west to the Fiji Islands on the east, and reaching northward to Japan—the most important feature which is thus rendered prominent being the presence of northern or representative northern species of Starfish in the Korean seas.

Turning now to the Echinoidea, it will be found that, of the ten which have been enumerated above, five are additions to the Japanese fauna, viz. *Temnopleurus Reynaudi*, *T. toreumaticus*, *Salmacis sulcata*, *Echinolampas oviformis*, and *Schizaster ventricosus*. Of these, *Temnopleurus Reynaudi* has hitherto been ranked as a more southern form, and having an extension westward as far as Ceylon; and similarly *T. toreumaticus*, which has a still greater westerly stretch to the Persian Gulf. *Salmacis sulcata* is likewise a more southern species, and with a distribution westward as far as the Red Sea; *Echinolampas oviformis* is quite a western form in relation to Japan; and *Schizaster ventricosus* occupies a southern area which ranges eastward to the Fiji Islands. Of the remaining five, which are known Japanese forms, two have a very wide distribution, viz. *Echinometra lucunter* and *Echinanthus testudinarius*, the former extending from the Red Sea to Australia and thence eastward to the Society Islands, and the latter occupying nearly the same area, but with a still greater easterly extension, reaching to California; *Echinocardium australe* extends southward to New Zealand and westward to South Africa,—none of the Echinoids above mentioned having a more northerly extension than some portion of the Japan islands. *Strongylocentrotus intermedius* reaches from Seghalion to Australia; and *Temnopleurus Hardwickii* is the only one whose limits extend no further southwards than Japan, whilst it reaches a latitude as far north as Unalaska.

From this conspectus it will be seen that all the Echinoidea, with the exception of a single instance, are those occupying a habitat which has a more southern and, in general, also a more westerly extension than the locality under notice.

It is especially noteworthy in this collection of specimens from



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KOREAN ECHINODERMATA

the Korean Seas, that whilst a large proportion of the Asteroids point to a northern centre of derivation, the Echinoidea, on the other hand, all belong to species having a southern and westward area of distribution.

DESCRIPTION OF PLATE VIII.

Fig. 1. *Astropecten formosus.* Abactinal aspect, natural size.
2. Actinal side of same specimen, about the middle of a ray, × 10.
3. Arrangement of the foot-papillæ on the inner portion of the ambulacral furrow, × 10.
4. Abactinal side of same specimen, about the middle of a ray, × 10.
5. *Cribrella densispina.* Abactinal aspect, natural size.
6. Actinal side of same specimen, about the middle of a ray, × 10.
7. Arrangement of the foot-papillæ, seen somewhat obliquely, and more highly magnified.
8. Abactinal side of same specimen, about the middle of a ray, × 10.
9. Madreporiform body of same specimen, × 10.
10. *Temnopleurus toreumaticus* (Klein), Ag. (?), juv.; profile, natural size.
11. Actinal aspect of same specimen, natural size.
12. Portion of test of same specimen, × 10.
13. Apical disk of same specimen, × 10.
14. *Echinocardium australe*, Gray. A young specimen 7·75 millims. in length; abactinal aspect, × 5.
15. Actinal aspect of same specimen, × 5.
16. Longitudinal profile of same specimen, × 5.
17. Portion of the posterior end of the test of same specimen, showing the separation of anal and subanal fascioles, magnified.

On some Ophiuroidea from the Korean Seas. By Professor P. Martin Duncan, M.B. (Lond.), F.R.S., &c. (Communicated by W. Percy Sladen, Esq., F.L.S.)

[Read June 6, 1878.]

(Plates IX.–XI.)

I. Introduction and General Relations of the Fauna.
II. List of Families, Genera, and Species.
III. Description of the New Species, and notices of those hitherto known.
IV. Remarks on the Species, and on their Affinities.
V. Description of the Plates.

I. *Introduction and Relations of the Fauna.*

Capt. St. John, R.N., in his late voyage in and about the seas to

the south and east of the Korea, dredged up numerous specimens of small Ophiurans, which were in company with several Asteroidea and Echinoidea. Dr. J. Gwyn Jeffreys sent me some of these specimens; and finding them very interesting, I was glad to avail myself of Dr. Günther's kindness when he placed in my hands the part of Capt. St. John's collection that had been sent to the British Museum, with a view to its being examined and named. Mr. Percy Sladen undertook, at my suggestion, the examination of the Starfish and Echini; and this communication is the result of my work on the Brittle-stars.

Situated near land which is rarely visited by Europeans, the Korean seas are to the south-west of the Japanese islands, to the north and rather to the east of Formosa; and the Philippines are many degrees to the south and a little to the west. Their floor was virgin ground to the dredger; and it was reasonably anticipated that some remarkable forms would be discovered in the fauna. It was interesting to notice, as the specimens were brought under careful examination, how several distant Ophiuran faunas were associated together, and represented not so much by identical as by very closely allied species. The peculiar grouping of certain genera very characteristic of well-known areas was to be traced in the fauna of this out-of-the-way locality.

One group of genera was not without its resemblance to those of the remote Smith's Sound and the North Atlantic; another recalled the familiar forms of the West-Indian seas; and a community of species with the Red Sea was noticed.

Out of the 16 species and several varieties, only three had previously been described from other localities, namely:—*Ophioglypha sinensis*, Lyman, from the China seas and Philippines; *Ophionereis dubia*, from the Red Sea and the Philippines; and *Ophiactis sexradia*, from the Pelews and Philippines, Nicobars and Tahiti.

Three of the new species of *Ophioglypha* belong to the group of the genus which contains the species *O. Stuwitzii*, *O. albida*, and *O. nodosa*; but they may be readily distinguished from these northern forms. The new *Ophiacantha* is interesting from its belonging to a genus of which a species is so commonly associated with the Greenlandic *Ophioglyphæ*; but it has characters which ally it to *Ophiacantha stellata*, Lyman, from Barbadoes. And the common *Ophiolepis* of the Korean seas, whilst having some abnormal characters, is not without some resemblance to the

immature *Ophiopholis*, the common associate of the well-known forms just mentioned. The group of *Amphiuræ* and *Hemipholis*, to which the Korean specimens belong, is characterized by the small number of mouth-papillæ; and they are allied to *Amphiura filiformis* and *A. squamata*, both Atlantic forms. The new species of *Ophionereis* and *Ophiothela* I have also recognized in a small collection of undescribed *Ophiuræ* from the Red Sea. The *Ophiothrix* of the Korean seas, with its numerous glassy spines and extremely variable disk and colour, does not come within any of the specific diagnoses of that very large genus, which is so fully represented in the Philippine seas.

Lyman and Lütken, especially, have shown the mimeticism and the similarity of generic and specific groupings of Ophiuroidea on both sides of the Isthmus of Panama, and the interesting representative character of the Ophiuroid faunas of the eastern African seas and of seas around the islands of the Pacific.

Having this world-wide distribution of closely-allied forms to deal with, it is not surprising that the difficulty of discriminating the species of large genera should be great. To this difficulty is added the extremely unsatisfactory multiplication of genera that has taken place, specific attributes often being regarded as generic, and parts of the generic diagnoses being frequently applicable to the type species and no other. It has been necessary to modify one genus, and to suggest the absorption of another after the examination of the form which I have termed *Ophiolepis mirabilis*: and in the instance of *Hemipholis microdiscus* a part of the Agassizian diagnosis must be discarded. One of the *Ophioglyphæ* is very like an Ophiomusian; and the remarks upon it will be found after the description of the species.

The fauna of Ophiuroidea, the result of dredging over a wide sea-floor, if it is an average of the whole, denotes conditions unfavourable to the large growth of individuals. The number of genera (ten) is small; and the excess of *Ophioglyphæ* is as remarkable as is the absence of several genera common in the Pacific. Thus *Ophiocnemis*, *Ophiopeza*, *Ophioplocus*, *Ophiocoma*, *Ophiarachna*, *Ophiarthrum*, *Pectinura*, and *Ophiopsammium* are not represented.

As a whole, the fauna is that of shallow water.

II. *List of Ophiurans collected in the Korean Seas.*

Order OPHIURÆ, J. Müller.]

Family OPHIOLEPIDIDÆ, Ljungman*.

Genus OPHIOGLYPHA, Lyman.

1. *Ophioglypha Forbesi*, sp. nov.
2. *O. striata*, sp. nov.
3. *O. sculpta*, sp. nov.
4. *Ophioglypha Sladeni*†, sp. nov.
5. *O. sinensis*, Lyman.

Genus OPHIOLEPIS, Lyman (amended).

1. *Ophiolepis mirabilis*, sp. nov.

Family AMPHIURIDÆ, Ljungman.

Subfamily OPHIONEREIDINÆ.

Genus OPHIONEREIS, Lütken.

1. *Ophionereis dubia*, Audouin, var.
2. *Ophionereis variegata*, sp. nov.

Subfamily AMPHIURINÆ, Ljungman.

Genus AMPHIURA, Forbes (modified).

1. *Amphiura Lütkeni*, sp. nov.
2. *Amphiura koreæ*, sp. nov.

Genus HEMIPHOLIS, Agassiz.

1. *Hemipholis microdiscus*, sp. nov.

Genus OPHIACTIS, Lütken.

1. *Ophiactis sexradia*, Grube.
2. *Ophiactis affinis*, sp. nov.

Subfamily OPHIACANTHINÆ, Ljungman.

Genus OPHIACANTHA, Müller & Troschel.

1. *Ophiacantha Dallasii*‡, sp. nov.

Family OPHIOTRICIHDÆ, Ljungman.

Genus OPHIOTHRIX.

1. *Ophiothrix koreana*, sp. nov.
2. *Ophiothrix koreana*, varr. nov.

Genus OPHIOTHELA, Verrill.

1. *Ophiothela Verrilli*, sp. nov.

Total species 16.

Species known before, from other localities.

1. *Ophioglypha sinensis* .... Hong-Kong.
2. *Ophionereis dubia* .... Red Sea.
3. *Ophiactis sexradia* .... Philippines.

* Ofversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, 1866, p. 303.

† Named after my friend Mr. W. Percy Sladen.

‡ In recognition of Mr. W. S. Dallas, Assistant Secretary of the Geological Society.

New species.

1. *Ophioglypha Forbesi.*
2. *O. striata.*
3. *O. sculpta.*
4. *O. Sladeni.*
5. *Ophiolepis mirabilis.*
6. *Ophionereis variegata.*
7. *Amphiura Lütkeni.*
8. *Amphiura koreæ.*
9. *Hemipholis microdiscus.*
10. *Ophiactis affinis.*
11. *Ophiacantha Dallasii.*
12. *Ophiothrix koreana* and varieties.
13. *Ophiothela Verrilli.*

III. *Description of the Species.*

Genus Ophioglypha, *Lyman.*

1. Ophioglypha Forbesi, sp. nov. Plate IX. figs. 1, 2, 3.

A very Ophiomusoid-looking form, but having tentacles as far out on the arm as the seventeenth plate.

The disk is pentagonal, rather thick, flat above, and is notched for the arms, which are slender and tapering. The scales on the upper part of the disk are large, few in number, and very regularly placed; there is a rosette, the central scale being pentangular, and the others are larger and rounder, and two large rectangular scales reach from its circumference to the interradial space, which is filled by them, and one even bends downwards below the upper margin. One or two very small scales are at the edges of these larger. A small scale separates the radial shields within. The radial shields are large, about as broad as long, curved at the free side, straight at the edge over the arm, united by the greater part of their inner side, and broad and blunt at their end near the rosette. The notch for the upper arm-scale is small, and there is some swelling of the shields near their junction. The radial scales are large, long and broad, and the curved free edge is armed with about ten or more short, distinct spinules, which, diminish in size as they merge into some very minute ones at the edge of the generative plate, close to the mouth-shield.

The interbrachial space, below the margin of the disk, is occupied by a large scale, which reaches to the distal edge of the mouth-shield: there is a small scale with a slight boss on it between this scale and the generative plate. The mouth-shields are large, occupy nearly the whole of the space between the arms, and are longer than broad; they are broad without and rounded; the sides are long and rather straight; and quite within there is an angular process with a sloping rounded shoulder, which forms the sides

and bounds the generative slit. The side mouth-shields are large and oblique, rather broad, and are united at their inner edge, which is produced between the jaws; the aboral edge is in contact with the angular process of the mouth-shield.

The jaws somewhat resemble the side mouth-shields in shape; they are short, wide apart without, are united within, and are rather projecting downwards. The mouth-papillæ are broad, short and close, and the innermost of each angle is small and diamond-shaped. The others, equal in height, form a linear surface, which is continuous, and the separation of the papillæ is only indicated by faint line. The outermost is the broadest, and there are in all eleven to each angle including that at the apex.

The outer end of each jaw reaches to the opening for the tentacle, or to the side of the first lower arm-plate.

The lower arm-plates.—All are separate, from the union of the side-plates in the median line. The first, although differing in shape from the others next in succession, is as large as they are; it is very peculiar in shape, being something like that of the blade of a hatchet. The margin within is narrow and notched, the outermost teeth fitting therein. The sides are re-enteringly curved, and within they bound the tentacle-opening and support three close, short tentacle-scales, and without they expand, where the plate becomes broad at its distal end, which is broadly curved, with rounded edges.

The next plate is broader than long, angular within, curved without slightly; and the sides, in one part rather straight, become curved where the side-plate passes obliquely to join its fellow along the median line. The third lower arm-plate is not so broad as the second, and has the same general shape. At about the twelfth or thirteenth lower arm-plate the size is much diminished, and the plate ceases to be recognized at about the twentieth joint, which is close to the tip.

The side arm-plates unite below along the median line and separate the first lower arm-plate from the second, and the second from the third very definitely; and from this point the length of the junction increases, and is greater than the length of the lower arm-plate. Further down, the side arm-plates nearly form the whole of the joints; they are broad and spread out wider without than within. A small, short, subspiniform tentacle-scale is on each side-plate, just external to the side of the lower arm-plate; its direction is longitudinal, and it protects a long slender

tentacle. The tentacle-scale becomes microscopic towards the seventeenth joint, and minute tentacles are seen thus far out.

The first tentacle-opening, slightly curvilinear, has four broad, but short, close, straight-edged tentacle-scales, two on either side. The next has a short ridge and a spiny scale on the side arm-plate, and a raised rim on the lower arm-plate; and the third has a small scale on the side arm-plate alone.

The upper arm-plates near the disk are boss-like. There are two small plates within the notch which are broader than long, close and convex from side to side. The next plate is overlapped slightly by the second, is boss-like and convex, strongly rounded without, and the sides slope in towards the disk. The fourth upper arm-plate is separated from the third by the side arm-plates, and is irregularly heart-shaped and boss-like and convex, especially distally; it forms about one half of the breadth of the joint, the rest being made up by the expanded distal part of the side-plates. The succeeding upper arm-plates diminish in size in all directions, and become more angular; and the last is seen on the twelfth or thirteenth joint.

The upper parts of the side arm-plates unite in long median lines; they are constricted within and expanded distally. Three very short stumpy arm-spines are in a depression on the side of the plate, close to the edges. The upper spine is the smallest, and they are unequally distant.

Locality. Korean Straits, 51 fathoms. Collected by Capt. St. John, R.N.

Ljungman has established the genus *Ophiothyreus* in order to separate one species, *O. Goesi*, Lj., from *Ophiomusium*, Lyman (see Stockholm Œfversigt af Kong. Vet. Förh. 1871, published in 1872, årg. 28, pp. 619, 620). This genus is characterized, amongst other peculiarities, by papillæ, some fifteen in number, projecting downward on the margin of the innermost arm-plate ("margine ad scutellum brachiale intimum vergenti papillifero"). The innermost upper arm-plate, large and triangular, is divided into two parts—the under arm-plates "inter sese tangentia," and the side arm-plates "ad brachium medium versus primum inter sese paullum tangentia." There are two squamiform ambulacral papillæ "ad ternas," and two minute arm-spines reaching, like the papillæ, to the third plate only.

This genus has Ophiomusoid characters, especially in the absence of the tentacles from the distal arm-divisions; but the

divided upper arm-plate suggests, according to Ljungman, the alliance with *Ophiolepis*. It is not without affinities to *Ophioglypha*, but it differs materially and generically from the new form described above.

OPHIOGLYPHA STRIATA, sp. nov. Plate IX. figs. 4, 5, 5*a*.

An *Ophioglypha* with striæ on the proximal side margin of the side arm-plates.

The disk is pentagonal, thick, flat above, straight and high in the interbrachial spaces, strongly notched for the arms; and the numerous scales are flat, overlapping, and inconspicuous. The central scale is large, and is surrounded by five small ones, succeeded by five large and some small scales, the rosette being indistinct. A medium-sized scale separates the radial shields at their inner angle; numerous scales pass towards the interbrachial space, where there is a central line of large ones bounded by two rows of smaller scales.

The radial shields, small and irregular in shape, are separated within, are then united for a short space, and are parted externally by the long convex upper arm-plate, which is fringed with a row of rudimentary spines at the sides. Sunken at the edges, the shields, about as long as broad, are bounded aborally by a straight or by a curved edge, into which the large radial plate fits on either side. In young specimens a small plate occurs, besides the first arm-plate in relation to the radial shields, and fills up the angle more or less; but with growth this becomes an important plate, and is not then distinguishable from the first arm-plate.

The radial plates are rounded, large, tall from below upwards on the side of the arm, broad above and narrow below, where they seem to merge into the generative plates. They form a conspicuous part of the interbrachial space, and are armed with about fifteen short spines, which are sharp and distinct above, and which unite and form broad expansions below.

The convex upper arm-plate, the rounded radial plates, and the colour (a faint grey) of the radial shields renders the parts over the insertion of the arms very remarkable.

The mouth-shields are large, occupy nearly all the space below and between the arms, and even are bent upwards slightly at the lower part of the tall interbrachial space; they are longer than broad, broadest and roundly curved aborally, narrower and more sharply curved orally, where there is a slight point, and the sides

are rather straight without, and converge more definitely within. All are slightly convex, and the madreporic is the largest.

The side mouth-shields are small; they are largest near their inner junction, and they have a round small outer lobe, which bounds the first tentacular opening aborally. The jaws are broad, short, and are tumid near the plate, and they support numerous mouth-papillæ. There are from eleven to thirteen papillæ, all of which are small, to each mouth-angle: the first resembles a true tooth, is the longest, and is angular and sharp; the next are smaller and are rounded, and the others are mostly little narrow bands, more or less separated, here and there, and rounded. There are four teeth, which are long, flat, narrow, and pointed.

The arms, five in number, are about once and a half the length of the diameter of the disk; they are broad and high at the disk, and taper gradually, and retain their great development at the sides to their tip.

The lower arm-plates within the disk have a more or less bold longitudinal convexity with a broad expansion on either side aborally. Broadest without, the plates are curved and are slightly hexagonal, the side arm-plates being joined to the small margins on either side of the distal end, and the rest of the side giving support to the curved, short, flap-like set of ambulacral papillæ.

Beyond the disk the lower arm-plates lose the convexity, are at first about as long as broad, and then become longer towards the tip of the arm. They are hexagonal and broadest aborally, and the oral edge, nearly straight, is the broadest, the opposite one diminishing gradually to a point where the side arm-plates come in contact, very close to the end of the arms. At that part the lower arm-plate is more elongato-quadrangular and broadest aborally.

The lower arm-plates support on either side, aborally, a row of thin, short, curved, flap-like processes, which are tentacle-scales. They are usually five in number, are close, split up often and very irregular; but those which are nearest the aboral part of the plate are the largest, and the others diminish rapidly in size. These scales diminish in size and number rather rapidly towards the mid arm, where there is a rudimentary tentacle-scale, and it is lost towards the tip.

The upper arm-plates vary much in shape and size; the first, in the larger specimens, is within the angle of the radial shields, and is rather convex, about as long as broad, rather pointed, and

with curved sides within, and with straight sides and a straight or curved edge aborally. In small specimens there is a small scale quite in the angle of the radial shields. A ridge, more or less dentated with minute spines, is on each side, and it is continuous with one on the next arm-plate, and it merges into the upper spines of the side arm-plate. The second arm-plate is broader than the other, broadest and curved without, with sides sloping to the smaller oral end. The next plate, also nearly quadrangular, is broader than long, slightly curved without, and nearly straight within. The fourth plate is hexagonal, broader than long, broadest without; and the edges are straight at the sides, and curved elsewhere slightly. The other upper arm-plates are hexagonal, longer than broad, with the greatest width externally; and towards the tip the length increases and the edges within and without become almost points. All are slightly convex from side to side, giving a keeled shape to the top of the arm.

The side arm-plates are important members of the arm; but they form the tall sides, and but little of the upper and lower surfaces. They are therefore tall, broad, and slightly curved at the free edges. They lie close to the side of the arm, where their breadth is very equal; and on their oral side, beneath the overlapping, ill-developed, semilamellar spines of the outer edge of the antecedent plate, there is a row of *linear striations* corresponding apparently with the spines. Above, there is an angular process of the side arm-plate which articulates with the sides of the upper arm-plates; and quite at the end the side arm-plates meet above.

On the lower part of the arm a very slender process of the side arm-plate is in contact externally with the second lower arm-plate; and the next and following side arm-plates join the lower arm-plate on the increasingly wide distal lateral side of the hexagon. In mid arm the side arm-plates encroach more on the arm-plates, and finally near the end separate them and unite. They form much of the under part of the arm; and they are swollen and convex towards the under part of it. The tentacle-openings down the arm are rather large, linear and broad, and increase in size towards the disk. Low down the arm there are only rudimentary tentacle-scales on the side arm-plates. The spines are on the edge of the side arm-plates, and do not project outwards; they are thin, lamellar, or rarely pointed, and are numerous occasionally when the ordinary lamellar condition is split up.

The tentacle-opening nearest the mouth-angle is large, oblique, and linear, and there is a margin of about from ten to twelve short and broad, blunt, lamellar tentacle-scales, one half being on the lower arm-plate. The next opening has about six scales on the side arm-plate; and so has the third. The tentacle-scales gradually merge into ordinary spines along the edge of the succeeding side arm-plates, and gradually become fewer and fewer.

The diameter of the disk between opposite interbrachial spaces is $\frac{3}{10}$ inch, and the length of the arm is about $\frac{5}{10}$ inch.

Locality. Sondai Bay, Korean Sea. Collected by Capt. St. John, R.N.

In the British Museum.

OPHIOGLYPHA SCULPTA, sp. nov. Plates IX. & XI. figs. 6, 7, 8, & 35.

The body is thick, pentagonal in outline, with well-marked slits for the arms, which are broad and high near the disk, tapering and short, being never more than once and a half the length of the diameter of the disk.

The upper surface of the disk is covered with large, medium-sized, and a very few small, overlapping, stout, rather tumid scales, which are often marked with minute dot-like cavities, and with short straight furrows close to the edge. A central rosette is formed of six, close, large plates, without any others intervening; the central plate, somewhat irregular in shape, is not overlapped. There are two large scales placed radially, which reach from the rosette to the edge of the disk in each interbrachial space; and three small scales, running parallel with the rosette, reach from it to the proximal separation of the radial shields, into which the central one fits. The radial shields are small, irregular in shape, are much overlapped, and are largest and broadest at the notch without; they are united and even overlap for a short space, and are narrow within. They are tumid, rounded off, and marked with pits.

The interbrachial spaces are large, slightly re-enteringly curved, and slope inwards and downwards. They are covered by numerous, small, very projecting, tumid scales in mosaic, and are much furrowed from side to side. A comb of very small, sharp, slender spinules is on the radial scale on either side of the notch, and it is continuous below with a spined edge of a generative plate. There are about twenty to twenty-four spinules.

The mouth-shields are small, longer than broad, very prolonged and angular within, and broad and nearly circular without: there

is a slight shoulder where the angular part joins on to the rest, on either side, and it marks the line of contact, without, of the side mouth-shield and the end of the wide generative opening. The angular part is enclosed by the obliquely placed side mouth-shields, which are joined within broadly, and which are rather swollen.

The jaws form a short broad angle, and are rather swollen longitudinally close to the mouth-papillæ. There are three small spiniform mouth-papillæ at the apex—one at the angle over the teeth, and one on either side. The other papillæ are long, low, thin ridges, sometimes separated slightly into four indefinite masses on either side, that nearest the spiniform teeth being pointed. The papillæ are small. There are five teeth, the uppermost being the largest; they are small, narrow, projecting, flat and spear-headed.

The upper arm-plates.—The first, seen close to the notch and within the radial shields, is rudimentary. It is a broad, very short lamina, with some rudimentary spinules upon it on either side. The second is small, broader than long, curved without (re-entering), and tumid; it carries spinules on its sides. The third, much larger, and often the largest on the arm, is broader than long, broadly heart-shaped, the broad rounded angle within being sometimes overlapped, and the large distal curve is produced to a slight angle on either side. The seventh plate is pointed and angular within, and much rounded without; length and breadth nearly equal; and it is separated from the eighth by a slight median union of the side arm-plate. At the end of the arm the upper arm-plates are greatly separated, are broader than long, and heart-shaped, forming a minute prominence. The plates near the base of the arm are swollen, especially distally, and the surface is marked by minute radiating lines.

The under arm-plates.—The first is about as long as broad, smallest and bluntly angular within, largest and re-enteringly curved without, and more or less triangular, with the angles cut off or curved; the centre of its surface projects slightly. The second plate is larger, nearly square, with curved corners, narrowest within, sloping at the sides, projecting in the middle, and marked with short furrows; its proximal edge is slightly curved towards the disk, and the edge, without, has a very faint notch and a broad shallow re-entering curve. The third plate, squarish, is broadest without, and the next has a very decided distal curve. All project and are marked at the sides. The eighth is small,

broader than long, angular and sharp within, curved broadly without, with short straight sides; it is convex, and separated from those next to it by the side arm-plate junction. Towards the tip of the arm the lower arm-plates are very small, widely separated, and about as broad as long, angular within and broadly curved without.

The side arm-plates are largely developed and form much of the arm. They are long, broad, stout, and flap-like, standing away from the arm at the base, especially below. They are closer to the arm lower down, are convex and swollen, and have large slits between them. They meet below between the seventh and eighth lower arm-plates, and gradually form much of the lower surface of the arm. They form the whole of the thick side of the arm and a large portion of the upper surface also. Above, they are close to the arm, are swollen and long, and their distal edge is curved gracefully. They unite between the seventh and eighth plates, and form much of the end of the arm. There are eight spines on the third side arm-plates; and they are not quite on the middle of the free edge, but on its outside, the tentacle-scales being nearer the other edge. The spines are very short, often flat, rounded and sharp, unequal, and some are broader than others. Towards the end of the arm there are five subequal spines, all very short.

Tubercle-scales.—The tentacular opening, at the side of the first lower arm-plate, is long, and there are four moderate-sized scales on either side of it; the second, not so long, has three more or less perfect, flat, short, rounded tipped scales on the side arm-plate, and two on the side of the lower arm-plate. About the sixth or seventh plate there is a tentacle-scale on the side arm-plate and on the lower arm-plate; and then they frequently, but not invariably, cease to be noticed, the small one on the side arm-plate often remaining.

A smaller specimen than the type, and having the disk about one half the size, shows some variation in structure which should be noticed.

The principal disk-scales are represented, but are slightly compressed; they have the patterns of dots and furrows on them. The first and second upper arm-plates have spines on them; and the side arm-plates unite, either between the fourth and fifth or the fifth and sixth upper arm-plates. Beneath, the tentacle-scales are carried on nearly to the end of the arm on the side arm-plate,

but only to the sixth or seventh lower arm-plate; and their lamellar nature is remarkable. The mouth-plates are more distinct.

Several still smaller specimens show the general arrangement of the disk-scales, have a spine here and there on the second upper arm-plate, and the side arm-plates unite above between the second and third upper arm-plates. Beneath, the tentacle-scale ceases on the fifth lower arm-plate, and the side arm-plates join between the third and fourth or fourth and fifth lower arm-plates. The jaws are thicker and the mouth-papillæ are less developed than in the larger forms. There is a tendency of the tentacular scales to form ridges, and of the spines to split.

Locality. Korean Straits, 23 fathoms. Collected by Capt. St. John, R.N.

In the British Museum.

Ophioglypha Sladeni, sp. nov. Plate IX. figs. 9, 10, & 11.

The disk is pentagonal, thick, much notched above the arms, which are short, straight, and tapering, and not quite twice as long as the diameter of the body.

The upper surface of the disk is covered with numerous rather tumid scales of all sizes, disposed without much regularity, sometimes overlapping and usually in mosaic. A large central scale is circular in outline, and has a slight boss on it, and four large scales of the rosette with a small one surround it, being separated by smaller scales. Each of the outer large scales has three smaller ones on its distal edge, the central scale of the three being fixed in between the radial shields.

The radial shields are longer than broad, have their inner and outer ends nearly equal, and their inner sides united for a short space, and the outer sides are curved; separated slightly orally by one scale, they are widely apart without and are placed obliquely. The shields do not reach the margin of the disk, and each terminates without in a long radial scale, curved without and furnished with fourteen close, distinct, short, slender spines. The interbrachial spaces are straight and they are boldly scaled. The mouth-shields are large, and reach without, close to the vertical margin of the interbrachial spaces; they are longer than broad, with a very pointed angle within and a broad curve without, the sides sloping from the broad base to the sharp angle.

The side mouth-shields are small, short, narrow, and united at

their inner edge; they are in contact with the distal third of the mouth-shield, and reach the generative slits.

Jaws short and converging; tooth-plate large; mouth-papillæ eleven to each angle. They are small, short, and the outer are broad; the innermost is sharply rounded and spearhead-shaped, and the next are smaller and sharper, the others resembling the outermost. There are four teeth, which are long, narrow, thin, and rounded.

The lower arm-plates are small, have a central longitudinal projection, are longer than broad, and have flat sides. The first is the largest, and the next few are close, slightly broadest and curved without. In mid arm (twelfth plate) they are elongated heart-shaped or verging on the hexagonal, and are slightly separated by the side arm-plates.

The upper arm-plates.—The first and second are within the notch: the one is very small, triangular, curved without, narrow within; and the other, much longer, is nearly square, and convex from side to side. The third, shorter than the second, is broader than long, is slightly overlapped by the second, convex from side to side, especially at its distal end, where it is curved. The fourth, broader than long, is broadly curved distally, where it is prominent and convex; it is narrower within, the proximal edge being overlapped by the third plate. The succeeding plates become more and more angular within, are broadly curved and projecting without, and are longer than broad. At the tip the plate is very small and heart-shaped.

The side arm-plates widely separate the others at the tip of the arm, and separate the upper plates slightly at about the eighth joint; and the fourth upper plate is encroached upon by the prominent broad flaps of the side arm-plates. The side arm-plates are, on the whole, well developed, for the arms have large sides; they have large flaps, which are tumid and swollen below and convex above; they are close to the arm.

Their free edge has spines on it, which are directed towards the end of the arm, and near the disk, on the side of the arm, on several side arm-plates, there is a solitary, sharp, short spine on the body of the plate and remote from the others. On some side plates it is close to the other spines. The spines on the edge are short, small, close, sharp, slender, and some are flat; they are rather irregular in breadth and length, and a long one is usually innermost on the top of the arm. Beneath, one or two spiculate sharp spines, longer than the others,

are seen external to the tentacle-scales. There are eleven spines on the fourth plate, and further out they are six and then four in number. The tentacle-openings are large and long: the first has four or five close, short, rounded scales on either side; and the second has five subspiniform scales on the side arm-plates, and four small blunt ones on the lower arm-plate; the next opening has the same number of scales, and then four are found around some, the number diminishing to one. The flat scales on the lower arm-plate cease at the sixth, where they are nearest its distal end.

Locality. Korean Sea. Collected by Capt. St. John, R.N.

In the British Museum.

OPHIOGLYPHA SINENSIS, *Lyman, Illust. Cat. Harvard Mus.* no. vi. p. 12 (1871).

Many small specimens of this species were found in 40 fathoms in the Korean Strait by Capt. St. John, R.N.

In the British Museum.

Genus OPHIOLEPIS, *Müll. & Troschel.*

OPHIOLEPIS MIRABILIS, sp. nov. Plates IX. & X. figs. 12, 13, 14.

The disk is large, swollen above, circular in outline, and without arm-notches. The arms not more than twice the diameter of the disk in length, are broad at the disk and taper rather suddenly, becoming small towards their ends.

Above, the disk is covered with scales of different sizes and shapes; they and the radial shields are minutely granular, and are separated by continuous series of minute round scales in single or double rows, and sometimes a minute scale is produced into a short conical spine. The mosaic and regularity of ornament is exquisitely regular. The scales are in rosette centrally, and there are two large and some other scales in the interradial space. The radial shields are large, long, separate, broadest and rounded without, and angular and most distant within; they are convex, elongate pip-shaped, and are granular, and each is surrounded by a mosaic of minute convex scales. They are, moreover, separated by two or three moderate-sized scales, each of which is surrounded by minute ones. Several short, stout, and rather blunt spines are at the margin of the disk; and they become smaller and more numerous and crowded in the interbrachial space, towards the mouth-shield.

The mouth-shields are small and granular; they are broader than long, rounded without, angular within, where a reentering curve slopes to the rounded, but angular, sides. The madreporic is the largest. The side mouth-shields are large, and rather long and rectangular in shape; they reach on to the lower arm-plate.

The jaws are broad and short; the mouth-papillæ are large, thin and rounded, and there are six to each angle. Beneath the lowest tooth there is a broad rounded knob separating the papillæ. The teeth are ten or eleven in number, increasing in length and breadth from below upwards; they are straight or slightly guttered within. The jaw-plates are well-defined, and the lowest teeth form a funnel-shaped cavity leading to the close upper ones.

The lower arm-plates.—The first is rudimentary, and is bounded on either side by the very close ends of the side mouth-shields: the second is large, and the general shape is much broader than long; the inner edge is grooved and concave; the outer, the longest, is nearly straight or slightly concave. The sides are slightly incurved for the tentacle-scale, and the corners are slightly rounded. The plates are separate; and the union is by a skin, the side arm-plates not reaching between. Near the tip the plates become longer and are still separate.

The side arm-plates are small, project from the side of the arm, have four short spines on the edge, and a large tentacle-scale which extends along the side of the lower arm-plate. The spine next to the scale is the smallest, and becomes a three-spined hook near the tip of the arm. The spines are conical, broad below, bluntish, are faintly striated, and stand out from the arm. The surface of the lower arm-plates is granular, and there are indications of faint rings of colour on the arms.

The upper arm-plates are surrounded by a row of very small accessory plates, fourteen to eighteen in number; there is a large accessory plate at the side and rather without, where it simulates in size and position part of the side arm-plate; it is bounded, but not externally, by small accessories. The upper arm-plates nearest the disk are small and more or less rudimentary, are broader than long, and they are crowded by the rows of small accessory scales: after the fourth or fifth, the others become large, oval from side to side, and much broader than long. In some specimens one of the edges is often straight. Further

out they become longer than broad and more or less oval, and the small accessory plates diminish in number and cease, but the large side accessories project. Towards and at the tip the accessories are not seen, as they gradually diminish in size, and the side arm-plates separate the upper arm-plates, which become very small.

The tentacles within the mouth are large and stumpy, and those of the arm are longer than the large tentacle-scale. The colour of the whole is light brownish red, and there is a blotch of dark colour on the radial shields and sometimes on the centre of the disk. The arms are dark red-brown close to the disk for a short space, and then they are slightly ringed with alternate dark red and light buff. In some instances the spines in the interbrachial spaces are dark-coloured.

There is much variation in the colouring and marking; and as the animal dries, the colours become lighter, the red disappears and is succeeded by a buff tint.

Locality. Sondai Bay, Korean Sea. Collected by Capt. St. John, R.N.

In the British Museum.

Genus Ophionereis, *Lütken.*

Ophionereis variegata, sp. nov. Plate X. figs. 15, 16.

The disk is flat above, circular in outline, and small; and the arms are moderately slender and tapering, and about four or five times the diameter of the disk in length. The colour of the upper part of the disk and arms is purple and light buff. The light tint is in four blotches on the disk, one in each interradial space, and the radial shields have a light mark on them, as have also all the scales and notably the few larger ones. The arms look banded with the light and dark tint; and two or three upper arm-plates are darker than the succeeding one, and have, besides, a longitudinal light area and a little spot near the end, besides lateral purple stripes and tinting. The accessory plates are generally tinted light purple, and some of the spines are banded. Beneath, the colour is light buff; and there is no colour ornamentation until quite at the tip.

The disk-scales are small, numerous, and without order; and the radial shields are very small, swollen, long-oval in shape, and very distant. Beneath, the scaling is distinct and small, and there is no other colour than the common light tint; it reaches close to

the mouth, and is bounded by the ridge of the generative slit on either side; and this is very minutely spined, the row of spines meeting close to the mouth-shield.

The mouth-shields are small, slightly longer than broad, cordiform, angular within, and curved broadly without, the madreporic being rounder in outline. They are remote from the margin of the disk, and are attached aborally to the process of the converging generative slits. The side mouth-shields are rather large, bound much of the mouth-shield, are narrow and united at their inner edge, and rather broad and triangular near the lower arm-plate.

The jaws are short, and together they form almost a semicircle, instead of an angle, and are broader than long. There are eleven mouth-papillæ to each angle; the last but one, externally, is the largest, and that at the angle resembles a small true tooth; those on either side project, but are rather blunt. The teeth are broad, and rather square at the free edge, and are five in number.

The under arm-plates vary slightly in shape, and those in mid arm are very broad aborally, rather angular within, but still, on the whole, are longer than broad. There is a slight curve aborally, where the plate forms not only the under arm, but encroaches on either side: there is a re-entering curve on either side for the tentacle, and then the sides slope sharply inwards, and the oral edge is short and approaches a point, or the oral portion of the plate may present a sharp and narrow curve.

The side arm-plates encroach by a blunt process upon the under surface, and produce the angularity of the under plates, but they do not separate them entirely.

The upper arm-plates overlap, are broader than long, and have a broad curve aborally and a faint longitudinal ridge; they are convex from side to side, broadest and least curved within, and the sides slope inwards from the oral edge. There is an accessory plate on each side, and it is broader and curved without and angular within, being close to the side of the upper arm-plate, and not projecting beyond its bold distal curve.

The side arm-plate has a narrow process which reaches slightly towards the median line beyond the accessory piece, which is pretty constant to the tip of the arm. The side arm-plates are small, form much of the side of the arm; they are rather thick, project slightly from the arm, and their free edge, which supports

three small spines, is rather thick. The spines are short, rather stout; the middle one the largest, blunt, with a small base of attachment, and it rarely surpasses the upper arm-plate in length. The tentacle-scale is large and oval in shape.

Locality. Korean Straits, 33 fathoms. Collected by Capt. St. John, R.N.

In the British Museum.

OPHIONEREIS DUBIA, *Audouin*, sp., var. SINENSIS, nov.

This Ophiuran species was delineated with great exactitude by Audouin in Savigny's 'Descr. de l'Egypte,' 1809, pl. 50; and afterwards it was termed *Ophiolepis dubia* by Müller and Troschel, 'Syst. Asterid.' p. 94. Subsequently Lyman placed it in the genus *Ophionereis*, and termed it *Ophionereis dubia*, Lyman. The credit of discovery and of accurate representation clearly belongs to Audouin in the first instance.

Lyman states that the specimen figured doubtless came from the Red Sea, as the species is not found in the Mediterranean.

The form from the Korean Sea is well grown, and differs from the type as follows:—The lower arm-plates have a median notch and eminence; the spines are subequal, and they are rarely banded with colour. It has a marsupium, and doubtless, as was commonly the case in these Korean species, it was viviparous.

Locality. Korean Sea, with *Ophionereis variegata*, nobis. Collected by Capt. St. John, R.N.

In the British Museum.

Genus AMPHIURA, *Forbes*.

AMPHIURA LÜTKENI, sp. nov. Plate X. fig. 17.

The disk is tumid, swollen at the sides, and slightly constricted in the interbrachial spaces. It is covered with very small, subequal, overlapping scales, which are still smaller beneath.

The radial shields are small, long, and narrow; broader aborally, where they approach and sometimes touch, smaller and separated by a mass of scaly derm within, where they are more or less overlapped by scales.

The mouth-shields are somewhat diamond-shaped, about as long as broad, angular without and at the sides, and well-rounded within; the madreporic is the largest and is almost circular in outline. All are continuous aborally with a furcate

process, on the sides of which are the generative slits, and all project orally so as to be very close to the jaws. The side mouth-shields are very small, narrow, and triangular; they are separate within, and form a blunt process on the edge of the lower arm-plate without.

There are four mouth-papillæ to each jaw-angle; and there is an upper tentacle-scale, on either side, with its top close to the jaw. The inner pair of mouth-papillæ are separate, large, pine-apple-shaped with a point, and their attachment to the jaw is somewhat constricted: the outer pair are subspinous, long, compressed, often bent, and project downwards, being attached close to the junction of the jaws and the side mouth-shields. The jaws are short, stout, straight, and parallel; and the teeth are large, broad, short, and rather square at the edge. The tentacles of the oral apparatus are large and long.

The first lower arm-plate is very small and rudimentary; and the second to the fifth, which are covered by the disk, are longer than broad, rectangular, with the corners rounded; the inner and outer edges are slightly slanting, and the plates are slightly separate. In mid arm the plates are longer than broad, slightly swollen at the sides, straight without and also within, where there is often a faint notch or a re-entering distal curve. Towards the end of the arms the plates are longer, more swollen at the sides, and rather constricted within and without from the inward extension of the side arm-plate.

The upper arm-plates are broader than long in mid arm, and rather longer than broad near the disk and at the end. The first is small, and about as long as broad; it is heart-shaped, and the distal curve, the largest, is bold, whilst the opposite end is more angular; the second, overlapped slightly by the first, is longer and larger, as are the third and fourth; their greatest breadth is orally, where the broad curve is. A faint longitudinal coloured ridge is seen near the outer edge. The plates gradually increase in size, and become broadly oval in shape; and the side arm-plates, large on the side of the upper part of the arm, only permit them to touch by a small edge. At the end of the arm the plates are broadly curved without, and rather small and angular within.

The side arm-plates are large, and form much of the tall sides of the arm and part of its upper surface, although they do not absolutely meet until close to the end. Their free edge does not

project much; but its vertical dimensions are considerable, and the plates are separated by skin. The spines project at right angles to the arm from the free edge, and are short, stout, flattish, constricted at their attachment, swollen in the middle, and bluntly pointed. Near the disk there are six spines, the upper and lower ones projecting upwards and downwards respectively, and the others regularly radiating. The longest, which is either the third or fourth from above, is about the length of the upper arm-plate. Lower down the arm there are four spines, and three at its end, whose tips are less projecting.

There is one tentacle-scale, which is large, rounded, and flat, situated on the side arm-plate; and the tentacles are very long.

The colour of the disk is slaty, and of the arms reddish brown with lighter-coloured under arm-plates. The disk is $\frac{1}{10}$ to $\frac{1}{5}$ inch long, and the arm is about ten times as long. They are stout, broad, and much curved.

Locality. Korean seas. Collected by Capt. St. John, R.N.

In the British Museum.

AMPHIURA KOREÆ, sp. nov. Plate X. figs. 18, 19.

The disk is flat above, tumid, and constricted in the interbrachial spaces and rather thick; and the arms are broad, not much more than twice the length of the diameter of the body, arched above, flat below, and furnished with three small spines and two tentacle-scales. The upper surface of the disk is covered with scales of several sizes; there is a small rosette of middle-sized scales, and there is much small scaling in the interbrachial spaces, and the scaling of the lower part is equal and not very fine.

The radial shields are small, much longer than broad, and are completely separated by three disk-scales.

The mouth-shields are heart-shaped, longer than broad, rounded and longer without, very angular and pointed orally, with outwardly curved inner edges. The side mouth-shields are large, united, and thick at their inner edge, long, broad, and triangular, broader towards the lower arm-plate, and much in contact with the mouth-shield. The jaws are small, short, thick, close and straight; there are six mouth-papillæ on each angle, and an upper sharp tentacle-scale on either side. The two papillæ beneath the teeth are large, lumpy, and blunt, rectangular in shape, with the

corners curved and constricted at the jaw; the next is broad, curved, and often produced into a slight spine, and the outer one is broader, short and thin, like a ridge; and by its junction with that of the next angle, a sharp margin is formed as a boundary to the jaw space.

The first lower arm-plate is small, and the others are about as broad as long, broadest without, where the edge is faintly incurved, and angular within, where the edge is short from the incoming of the large side arm-plates. The side near the distal end is straightish and bears a tentacle-scale, and then it slopes inwards orally. Towards the end of the arm the plates are small, longer than broad, curved without, and more angular within, and are separated by the side mouth-shields.

The upper arm-plates are short, large, convex from side to side, much broader than long; they are strongly curved within, and nearly straight aborally, and towards the end they become separate and more pointed orally.

The side arm-plates are well developed, and have a thin inferior process between the under arm-plates, and a larger, which extends on the upper arm: they begin to encroach soon, and are in contact, at the tip of the arm, separating the lower plates. They project very slightly, and three short, slender, sharp spines arise from the free edge; these are smaller at the base, thin, slender, round in transverse outline, and are about the length of an arm-plate. A large tentacle-scale, rounded and broad, is on each side arm-plate, and is in contact with that of the lower arm-plate. The colour is white; the arms are curled downwards, and their length is about twice that of the diameter of the disk.

Locality. Korean Straits, 37 fathoms. Collected by Capt. St. John, R.N.

In the British Museum.

Genus HEMIPHOLIS, *Agass*.

HEMIPHOLIS MICRODISCUS, sp. nov. Plate X. figs. 20, 21, 22.

The disk is small, constricted at the interbrachial spaces; and the arms, about eight times as long as the diameter of the disk, are long and tapering. The upper surface of the disk has thin overlapping scales of several sizes, and there are faint indications of a rosette. A numerous series of smaller scales is in the midst of the interbrachial space above, and there are smaller ones on either side; and five radiating lines of longish scales pass between

the radial shields, separating them centrally. The radial shields are long, slightly curved, broad without where they join, narrow within where they are separated by three scales and are rather smaller. The disk is naked below; and the generative slits are large and long.

The mouth-shields are small, longer than broad, and heart-shaped; they are angular orally, and well curved without, and the madreporic, the largest, has a furcate process externally. The side mouth-shields are large, triangular, narrow at the inner edge, where there is incomplete junction, curved within, and large and expanded at the arm.

There are four mouth-papillæ to each angle; the innermost two under the teeth, are large, blunt and long; and the others are long, spiniform, with a narrow base of attachment, and sometimes their base is broad, and there is a division into two. There is a sharp spiniform upper tentacle-scale on either side. The jaws are rather separate without, stout and short.

The lower arm-plates are longer than broad, very slightly curved without re-enteringly, and the corners are rounded. The sides are nearly straight, and they slope towards the median line orally. The inner edge is short, and soon becomes angular.

The upper arm-plates are broader than long, slightly curved without, and with a broad and rounded angle within. The side arm-plates are well developed; and there are four short arm-spines, of which the upper and lower are the thinnest, and the others are stouter and blunter. They stand out radially, and have a narrow base of attachment, a broad lower part, and a tapering end, and they are striated and rough. Towards the end of the arm the spines are more slender and spiculate, and they are there usually three in number.

The arms are about nine times the diameter of the disk, whose diameter is $\frac{1}{10}$ inch. The free edges of the side arm-plates are wide apart, and naked skin exists between them on the side of the arm.

There are two small rounded tentacle-scales close together, one on the under arm-plate and the other on the side arm-plate.

Locality. Korean Straits, 51 fathoms. Collected by Capt. St. John, R.N.

In the British Museum.

Genus Ophiactis, *Lütken.*

Ophiactis sex-radia, *Grube* (sp.), *Wiegm. Archiv*, 1857, p. 324, under genus *Ophiolepis.*

This species was described by Lütken subsequently as *Ophiactis Reinhardtii*, and figured by him in tab. iii. fig. 7, in his essay on the West-Indian and Central-American *Ophiuræ*, p. 263, in noticing the species obtained by the corvette 'Galathea' from Nicobar and Tahiti.

The Korean specimen evidently belongs to this species; and thus the known distribution is from Zanzibar, Nicobar Islands, Korean seas, Sandwich Islands, and south to Tahiti.

Locality. Korean seas. Collected by Capt. St. John, R.N. In the British Museum.

Ophiactis affinis, sp. nov. Plates X. & XI. figs. 23, 24.

The disk is circular in outline, without arm-notches; there is a medium-sized, circular, flat scale in the centre, around this a number of others, which are smaller, forming an indefinite rosette; and a band of irregular-shaped scales passes outwards in each interradial space, with one or two rows on either side of smaller scales. The radial shields extend halfway to the centre, are separated by two scales, the outer of which is long and narrow, and the inner, producing the greatest amount of divergence, shorter and broader: the shields are nearly in opposition over the arms, and separated within; they are rather covered at the margins by the scales of the disk, and are long, narrow, and broadest without. The scales of the margin of the disk carry a few separate, rather wide apart, stout, short spines; there are more on the top of the disk, but in the interbrachial spaces below the scaling is small, and the spines become crowded, small, very short, thin, and numerous.

The oral structures are small; and four or five of the broad lower arm-plates are within the range of the disk.

The mouth-shields are small, triangular, very slightly broader than long, broad, and slightly rounded aborally, where there is attachment to a process continuous with the sides of the generative slit, bluntly angular, or more or less rounded within, and produced at the sides. The madreporic plate is rounded and larger than the others. The side mouth-shields do not meet within, but are large, triangular, with rounded edges, and are at the oral side of the mouth-shield; they unite with their neighbours on the under part of the first arm-plate.

The oral slits are large and wide; the jaws are slender and separate near the mouth-shield, and broader at the plate, where the broad teeth are attached. These are four in number, and the lowest has a re-entering curve to its free edge. There is a mouth-papilla, long, lamellar, rather produced downwards on the edge of the jaw close to the side mouth-shield; and beneath the true teeth there is a small broad lumpy papilla, somewhat resembling them, but much smaller in size.

There are five arms, which are about three or four times as long as the diameter of the disk; they are broad, and ringed with dark grey and green colour, especially above. The lower arm-plates are broader than long, broadest without, where there is a slight rounding or nearly a straight edge, narrower, but still wide within; and the sides are either rounded, to give an elliptical appearance to the whole, or are straighter, slanting decidedly near the oral edge of the plate. Towards the tip of the arm the shape becomes hexagonal, and the outer edge is nearly straight and broad, the inner being very short.

The upper arm-plates, on mid arm, are nearly twice as broad as long, overlapping, well rounded within, less so, or nearly straight-edged without, the sides being sharply curved, the whole being irregularly elliptical. At the tip they are longer and triangular, with the point within. They form much of the upper surface, even at the tip.

The side arm-plates are large, extend on the top of the arm in a broad process between the sides of the successive upper arm-plates, are flap-like, and stand out from the arm at the sides, and encroach more or less short of separating the lower plates below. Some have an accessory small spine at the edge of the plate above, towards its end near the median line; and all, except near the tip, have four short, radiating, rather wide apart, blunt spines on the edge. The lowest spine is the smallest, and the next is usually blunter and larger than the others. There are three spines near the tip. The longest spines are about the length of an arm-plate.

The tentacle-scale, one on each side, is large, oftentimes nearly as long as the lower arm-plate; it is narrow where attached, and broad and rounded slightly where free, and the length exceeds the breadth.

The diameter of the disk is $\frac{1}{8}$ inch. The bands on the arm are broad, and the dark grey-green tint occupies one or two upper and side arm-plates; then there is the usual greenish-buff tint on

two, three, or more before the next band. In some parts many plates are covered longitudinally with a stripe of the green tint. The edges of the radial shields and some of the scales of the disk are tinted with the dark colour, but the traces of it below are slight.

Locality. Korean seas. Collected by Capt. St. John, R.N.

In the British Museum.

Genus Ophiacantha, *Müll. & Troschel.*

Ophiacantha Dallasii, sp. nov. Plate XI. figs. 25, 26, 27.

The disk is small, pentagonal, and contracted in the interbrachial spaces. The radial shields are entirely hidden; but their outlines, long and narrow, can be traced beneath the covering, which, like that of the rest of the disk, is ornamented with microscopic stumps, each terminating in three wide-apart sharp thorns, there rarely being two and four terminal ones; stumps slightly larger in the centre of the disk.

The under surface of the disk is covered to the outer edge of the mouth-shields with the same texture, the thorned stumps being small and crowded. Each stump is on a rounded base, the aggregate of which form the membrane of the disk.

The mouth-shields are very small, heart-shaped, angular within, rounded without, and longer than broad; they are marked with a central splash of purple colour.

The side mouth-shields, much larger than the mouth-shields, are nearly united within, and extend on either side outwards beyond the broadest part of the mouth-shield, and come in broad contact with the first side arm-plate. These side shields are broad from side to side, and their inner edges long, are shorter than the outer, where the shield is largest; their outer edge partly bounds the generative opening. The jaws are short and broad from side to side, so that the angle is not a very acute one. The mouth-papillæ are seven on each angle; the inner one, below the teeth, is markedly larger and longer than the others, and it is somewhat in the shape of a long sharp fir-cone. The next and neighbouring papillæ are more spiniform, and the most external on either side are broader and shorter than the others. The teeth are four to each jaw, and they are longer than broad, and flat, rounded within.

The arms are about six times as long as the diameter of the disk, and are very nodose in appearance from the swollen nature

of the side arm-plates, close to their outer free edge. The arms taper rather suddenly, and are bent downwards after death, giving a very spidery look to the form.

The first under arm-plate is small, longer than broad, broadest within, where there is a slight re-entering curve in the midst of a convex inner border, and much narrower distally, where there is a rounded process separating the side mouth-shields, and terminating close to the junction of the first side arm-plates on the arm.

The second under arm-plate is much larger than the first; it is broader than long, projects slightly, and is broadly heart-shaped in outline. The inner part is angular, and the outer broadly curved, and the angular sides are rounded. The next arm-plate, separated by well-developed side arm-plates, which meet longitudinally along a straight line, is less angular orally; and the fourth arm-plate, much broader than long and smaller on the whole, has its sides slightly straighter than those already mentioned. The succeeding under arm-plates are smaller, have the sides straighter, and the distal curve is less developed than the oral. At the tip of the arm the lower plates are much smaller and widely separate, their sides are straight for a short distance, the curve is more intense without than within, and the whole is still broader than long.

The upper arm-plates are widely separated, small, slightly broader than long, angular within, faintly re-enteringly curved at the sides and well rounded distally. They are convex above. Near the tip of the arms they are strongly rounded without, and very convex above from side to side and from within externally.

The side arm-plates are strongly developed, and constricted proximally; each gradually swells out laterally, broadly, and also superiorly, so as to include the upper arm-plates in a considerable nodosity, which is only lateral inferiorly. They unite above, as below, in straight median lines, and the result is that a side view of an arm presents a tolerably straight condition of the lower surface, and a waved edge of alternate depressions and rounded projections of the upper surface.

The free edge of the side arm-plates, rather stout and projecting at the side of the arm, gives origin to four sharp, glassy spines as well as to a minute spinulose tentacle-scale. The spines are shorter than a joint, are spear-like, striated longitudinally, and are minutely serrate; the upper are the largest and longest, and sometimes a fifth exists near the disk. The texture of the arm-

plates is granular, minute glassy-looking granules being separated by a more opaque development.

The specific characters are the minutely bifurcate or trifurcate thorned condition of the upper and lower surfaces of the disk, the great side arm-shields, the nodose condition of the upper part of the arm, the great development of the side arm-plates, the four sharp spines, and the minute tentacle-scale.

The species represents *Ophiacantha stellata*, Lyman, from Barbadoes, 100 fathoms (Illust. Catal. Harvard Coll., No. 8, ii. p. 11). It differs from *O. indica*, Lym.

Locality. Straits of Brea, 50 fathoms. Lat. 38° 19′ N., long. 129° 7′ E. Collected by Capt. St. John, R.N.

Genus Ophiothrix, *Müll. & Troschel*.

Numerous specimens of a species and its varieties which belong to this genus are amongst the dredgings brought from the Korean seas by Capt. St. John, R.N. They all have numerous slender, long, serrate, and usually glassy spines on the arm, a broad under surface to the arm, disunited side mouth-shields, and a disk whose colour and armature are excedingly variable. The specific peculiarities and the curious amount of variability have been determined after the examination of about eighteen specimens.

Ophiothrix koreana, sp. nov. Plate XI. figs. 28, 29, 30, 31, 32.

The disk is usually circular in outline, and rarely pentagonal; it is rather thick, flat above, and swollen at the interbrachial spaces. The radial shields are longer than broad, narrow and rounded within, and broad without, where there is a short rounded projection over the arm. Closer without than within, they are often slightly separated by dermal tissue. Their outer margins are sunken, as it were, and rounded, and their surface is covered with a skin which supports a very few stumps, which may nearly be covered by them, and which may have spinules and even a short spine or two upon the surface. The stumps are swollen at the base, constricted in the cylindrical portion, and are armed with three sharp, slender, wide-apart thorns. The thorns are rarely two and four in number. The spinules are longer than the stump, and have longer thorns. The spines are glassy, slender, and toothed at the side.

The rest of the upper surface of the disk is crowded with stumps,

resembling those of the radial shields; and there are spines and spinules, in some specimens, near the centre.

Towards and on the interbrachial spaces, reaching in a triangular patch on to the under surface, are spinules, which become crowded inferiorly. They are slender, with swollen bases of attachment, and have long trifid thorns.

There is a reddish tint on the centre and in the interradial spaces, and it also sometimes encircles the whole disk as with a narrow band. The tips of the stumps and spinules are often red. The disk is covered with skin, under which traces of scales may sometimes be seen; and below the disk is naked beyond the patch of spinules.

Inferiorly, the disk-membrane joins on by two plates to the distal joint of each mouth-shield: the generative slits are large, and the generative plates are broad and large and very visible at the side of and above the arms.

The mouth-shields are small, broader than long, diamond-shaped, rounded at the sides, angular within and curved without, where there is union with the edges of the generative slit. The oral edges are slightly re-enteringly curved. The madreporic shield is elliptical and the largest.

The side mouth-shields are rather large; they are narrow at their inner edge where they do not unite, and they are broad and triangular where they are in contact with the first lower arm-plate. Their oral edge is curved, with the concavity towards the jaws.

The pairs of jaws are slender and are widely separate, and each jaw of the separate angle is distinct near the mouth-shield.

The tooth-papillæ are in a very long narrow oval; they are small, and crowded in a row of six or more inferiorly, and become gradually larger above until they approach the true teeth. Within the edge of the oval thus formed there is a well separated mass of tooth-papillæ in two rows, and they are larger than those around. The number of papillæ is variable.

The teeth are narrow, flat, slightly rounded, and sometimes have a boss on the free end; they increase in size upwards, but the highest is sometimes smaller than the others. There are five in all.

The lower arm-plates increase in size from the oral ring to where the arm is well free from the disk, and they retain a considerable dimension until the terminal third, where they decrease gradually. Their typical form is slightly broader than long,

broader without than within, with sides sloping inwards. The distal edge, wider than the other, is broadly curved, the convexity pointing orally; its angles are cut off and rounded; there is a re-entering curve at the sides, and the proximal edge is grooved, the concavity looking orally. The plates are rather separate and united by skin, and they are rather flat, and form the bulk of the under surface. They are usually without any special tint other than the light brown of the whole, but in some there is a pinkish line on either side close to the edge. At the tip of the arm the plates are longer, less incised, and are closer together.

The upper arm-plates are close, longer than broad, angular orally, with a straight edge there, and they are boldly rounded distally. They slope on either side from a median faint central ridge, which ends at the rounded extremity in a faint nodule. The sides slope to the angle, and are overlapped by the side arm-plates, and one upper arm-plate slightly overlaps that next to it. Near the tip the length of these arm-plates increases over the breadth. A white longitudinal line with a red or purple one on either side, of greater or less breadth, is often to be seen.

The side arm-plates are well developed, and stand out from the arm, forming with the connecting-skin much of the side-arm. Below the free edge extends outwards on a level with the surface of the under arm-plates, and supports short spines and the small tentacle-scale. Above, the inner end of the side arm-plate is prolonged into a short angular process with a curved margin, which overlaps and to a certain extent separates the upper arm-plates. This process has one or more long spines on its surface, and the others are on the free edge of the plate, where it forms the side of the arm. The plates extend on the under surface of the arm, but do not meet, and are broad enough to place the tentacle-scale well without. The scale is small, largest at the base, and minutely thorned.

The spines near the disk are numerous, and they vary from 9 to 12; further on they diminish to 7, 5, and 3 in number.

The spine next to the tentacle-scale is the smallest, and is a mere spinule, with a sharp thorn on the plates nearest the disk and for some distance, but soon the thorn becomes bent and a second one forms on its side, and there is a boss-like prominence below and near the origin. This two-toothed and curved hook increases in size towards the end of the arm, is glassy, and points orally. Sometimes there are three teeth. The next spine is slightly larger, is flat, tapering, serrated and striated, and often bushy at

the broad top, or its top may be sharp. Sometimes the denticles on the side are long enough to simulate hook-processes. The third is slightly larger, and the others increase in length and size, the maximum being reached on the shoulder of the arm, and before the process of the side arm-plate is reached. Occasionally on the top of the arm and on the extremity of the side arm-plate there is a smaller needle-shaped spine without denticulation. The spines as a whole are flat, striated, many-toothed, and end with a sharp brush of thorns, or are blunt and rarely simple at the termination. All have a distinct boss-like base, and are glassy when young, and more opaque when old and dry.

The specimens present the appearance of having been viviparous. The diameter of the largest disk is $\frac{3}{10}$ inch, and its longest arm is one inch in length.

Locality. Korean Straits, 23 fathoms. Collected by Capt. St. John, R.N.

In the British Museum.

Variation. The disk is sometimes pentagonal in outline. The whole of the disk is sometimes covered with a crowd of stumps and the radial shields also, but the spinules appear in the interbrachial space and have three long thorns.

No derm is seen in some specimens separating the radial shield from its fellow.

In young forms, the spines are shorter, sharper, with fewer teeth, and are sometimes not quite straight; the tooth-papillæ are not so numerous, the under arm-plates are longer and less curved without, and there are fewer spines on the side arm-plates.

This variable species is allied to *Ophiothrix spiculata*, Le Conte, and is the representative of *O. violacea*, Lk.

OPHIOTHRIX KOREANA, variety, sp. and var. nov.

The disk is circular in outline, and the interbrachial spaces below are very tumid and project, being tinted at the edge pale green, nearer the margin light red. The disk is coloured light reddish brown, and the numerous short trifid stumps on it are of a dark red colour. The arms are light red and violet in tint, and there is a light streak with darker colour running down the upper arm, the darker tint spreading. There is a line of dark tint on the under arm on either side. The stumps on the disk are separated and not crowded, and those on the interbrachial space are longer and not coloured, being trifid and glassy. The spines are seven or more towards the base, largely thorned and

glassy, and they are slender and long. The hooks are large, with two sharp processes, and are blunt. This is a young form of a variety of the last type.

Locality. Korean seas. Collected by Capt. St. John, R.N. In the British Museum.

Genus Ophiothela, *Verrill*.

(Notes on Radiata, Trans. Connecticut Acad. vol. i. part 2, page 269.)

Verrill has described a species *Ophiothela mirabilis*, and Lyman gives a drawing of the side-arm of a specimen (Illust. Cat. Harvard College, No. 8, ii. 1875, page 34, pl. iv. fig. 60). The species is from Panama Bay, Pearl Island.

Lyman has described a species *Ophiothela tigris*, probably from the Pacific (Illust. Cat. Harvard College, No. vi. page 10, pl. i. figs. 10–12, 1871); and Lütken has described *Ophiothela isidicola* from the Eastern seas (Ophiurid. nov., Overs. K. Danske Vidensk. Selskabs Forhand. 1872, pp. 92 & 107). Numerous specimens of this species were obtained by Semper from the Philippines, and are now in the Museum of Comparative Zoology at Harvard College.

A specimen which must be referred to this genus is amongst the collection of Ophiurans from the Korea, and instead of clasping some kind of *Isis* or any zoophyte, it clings to the arms of a blunt-spined *Amphiura*. Its habits are evidently those of the forms already described, and its flap-like side arm-plates, the well-developed hooks, and the skin-covered arms ornamented with rounded masses of carbonate of lime, the six arms and corresponding large close radial shields, bring it clearly within the genus. From Lyman's plates the Korean form differs, and it would appear to differ from the other species. I have some forms from the Red Sea which are closely allied to that now under consideration; and they all form a group characterized by the regular ornamentation of the disk, with short, thick, knob-shaped spines, having a broad foundation, the regular boss ornamentation of the upper arm and the semiglobose condition of the mouth-shields, and the presence on the distal free edge of the side mouth-shield of a club-shaped spine.

Ophiothela Verrilli, sp. nov. Plate XI. fig. 33.

The disk is rather thick, and the radial shields covered with a minutely and sharply granular skin. They have numerous very

distinct, irregularly placed, knob-shaped spines on them, which are not quite globose, having a blunt tip; they are minutely thorny at the top, and have a rather constricted peduncle and a broadish defined expanded base. The centre of the disk, where the shields do not reach, and the linear interradial spaces bear larger spines, six or seven in the centre and three or more elsewhere, but all have the same knob-shape and minutely spiny surface. Some on the interradial spaces are slightly elongate, and a large one is usually at the margin. The interbrachial space below and at the sides is ornamented with several of these spines. The generative plates are large and distinct. The upper surface of the disk contrasts with the skin-covered interbrachial regions. The mouth-shields and side mouth-shields, although fused and covered, are seen to be large. The distal end of the mouth-shield is globose; and the side mouth-shields, broad orally, are ornamented by a slender, downward projecting, club-shaped spine, sometimes forked close to the generative slit. The side mouth-shields do not unite externally, but only reach the under arm-plate.

The jaws are short, rather separate, parallel, rather swollen high up in the region of the upper tentacle, where there is a rounded spiny process. There are ten tooth-papillæ on an oval mass; and the angle is large, and projects rather downwards. The tentacles are long and large.

The under arm-plates are covered with a delicate skin; but the plates are visible and are separate, rather hexagonal, broadest without, where there is a notch, and angular orally, the line within being slightly notched. The outer angles are rounded, and the sides slope in straight. There appears to be a median depression, and the outer angles are swollen.

The skin on the upper arm-plates usually hides them, but they are rounded rather angularly distally. A series of solitary median large bosses passes down the arm, and two or three smaller ones are in a transverse line between them. These last do not exist at the tip, where the large boss is very distinct.

The side arm-plates have the characters of those of the genus; they are minutely granular at the sides and swollen, but there is no special ornamentation or keeling. The upper spine of the five is small and rugged, the next is larger and longer and often spiculate, the third is the largest and is denticulate within, and the others become strong hooks with the points looking orally down the arm. There are no tentacle-scales, and the long tentacles

come out from the side of the arm. The arms are about twice and a half as long as the diameter of the disk, which measures $\frac{1}{10}$ inch.

Locality. Korean seas, on *Amphiura*. Collected by Capt. St. John R. N.

In the British Museum.

IV. *Remarks on the Species.*

The first species of *Ophioglypha* (*O. Forbesi*) described is very anomalous from some points of great affinity to the genus *Ophiomusium*. The mosaic of the disk, the long almost connected mouth-papillæ, the meeting of the side arm-plates above and below, and the small size of the upper and lower arm-plates would connect the form with Lyman's genus *Ophiomusium*. But the papilliferous radial scales and generative plates, and the presence of a tentacle-scale and minute tentacle far out towards the tip, are not characters of that genus. The species is aberrant from the typical *Ophioglypha*, on account of the oral structures especially; and the disk scaling is to a certain extent abnormal. It is an interesting form, for it throws a light on the value of *Ophiomusium* as a genus. Its species as yet are remarkably widely separated, and it must be acknowledged that its characters are very embryonic. For the literature of *Ophiomusium*, see Bull. Mus. Comp. Zool. Harvard Coll. Cambridge, U.S., vol. i. No. 10, page 322. See also Wyville Thomson, 'Depths of the Sea,' vol. i. p. 172; 'Voyage of Challenger,' vol. ii. p. 67.

Ophioglypha striata, so called from the remarkable groovings on the side arm-plates, is also characterized by the structures about the notch of the disk, and the curious shape and spinulation of the first two or three upper arm-plates.

Ophioglypha sculpta is clearly an ally of *O. Stuwitzi*, and the furrowing and dotting of some of the scales and plates is very characteristic. The spiny condition of the first upper arm-plate is to be noticed.

Ophioglypha Sladeni is characterized by the accessory spine on the body of the side arm-plate, by the numerous spines near the disk and their irregular length, and the bossed disk scale.

Ophioglypha sinensis, Lyman. Numerous specimens of this rather aberrant *Ophioglypha* were dredged up. The scaling of the disk differs from that of all the other forms in the Korean seas.

Ophiolepis mirabilis. This common species has the disk of *Ophiolepis* as diagnosed by Müller and Troschel, that is to say

the scales, which are of good size, and the large radial shields are environed by rows of small scales as by belts. But the upper arm-plates have also the supplementary rows of small scales around them, and there are also large accessory side pieces. Moreover there are hooks on the side arm-plates. This mixture of Ophiolepian and Ophiopholian characters is very interesting; and this species, I consider, renders the abolition of *Ophiopholis*, as a genus, inevitable.

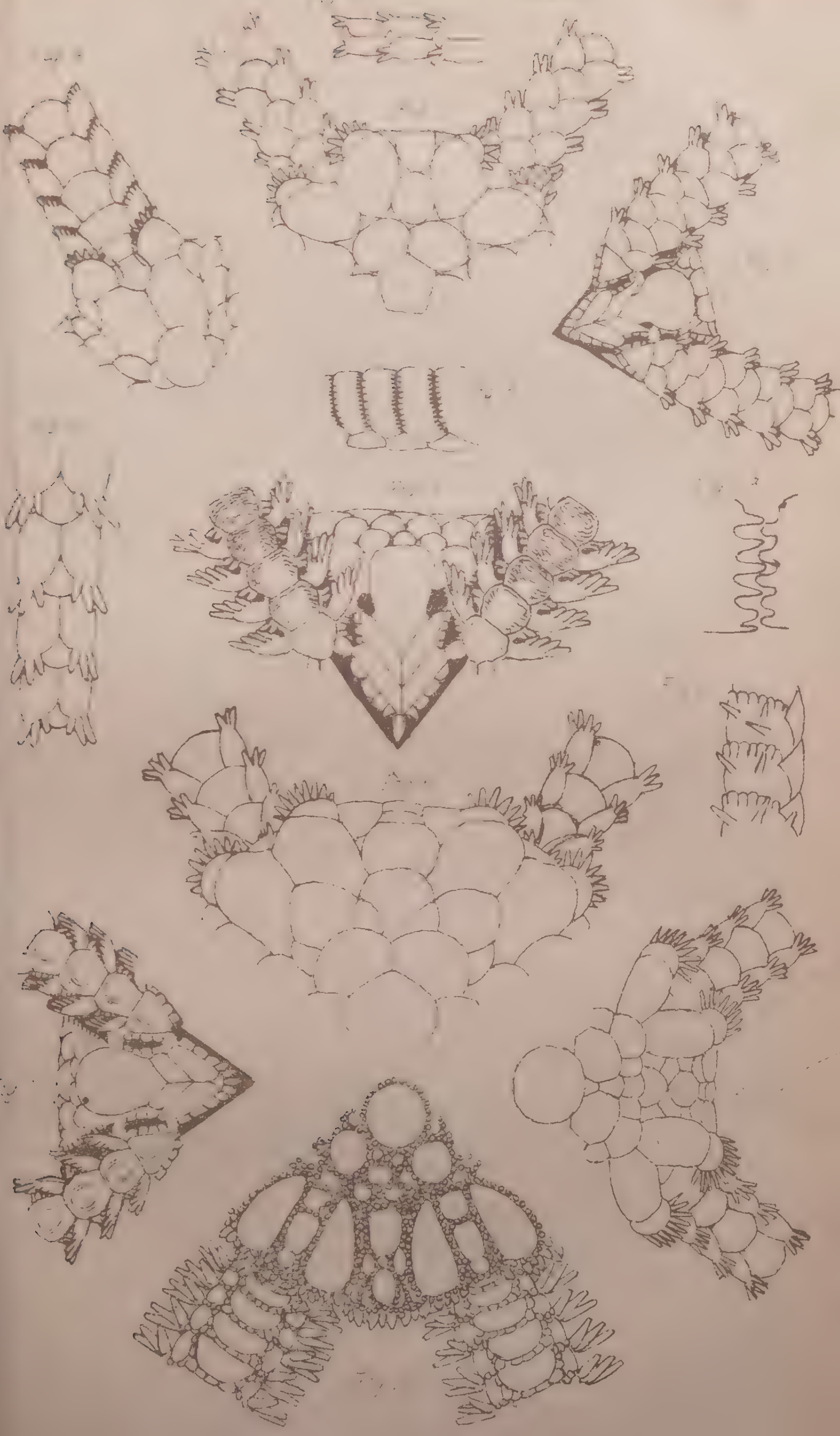
Ophionereis dubia is represented by a variety in the Korean collection; and the distinctions between the variety and the type have been already noticed.

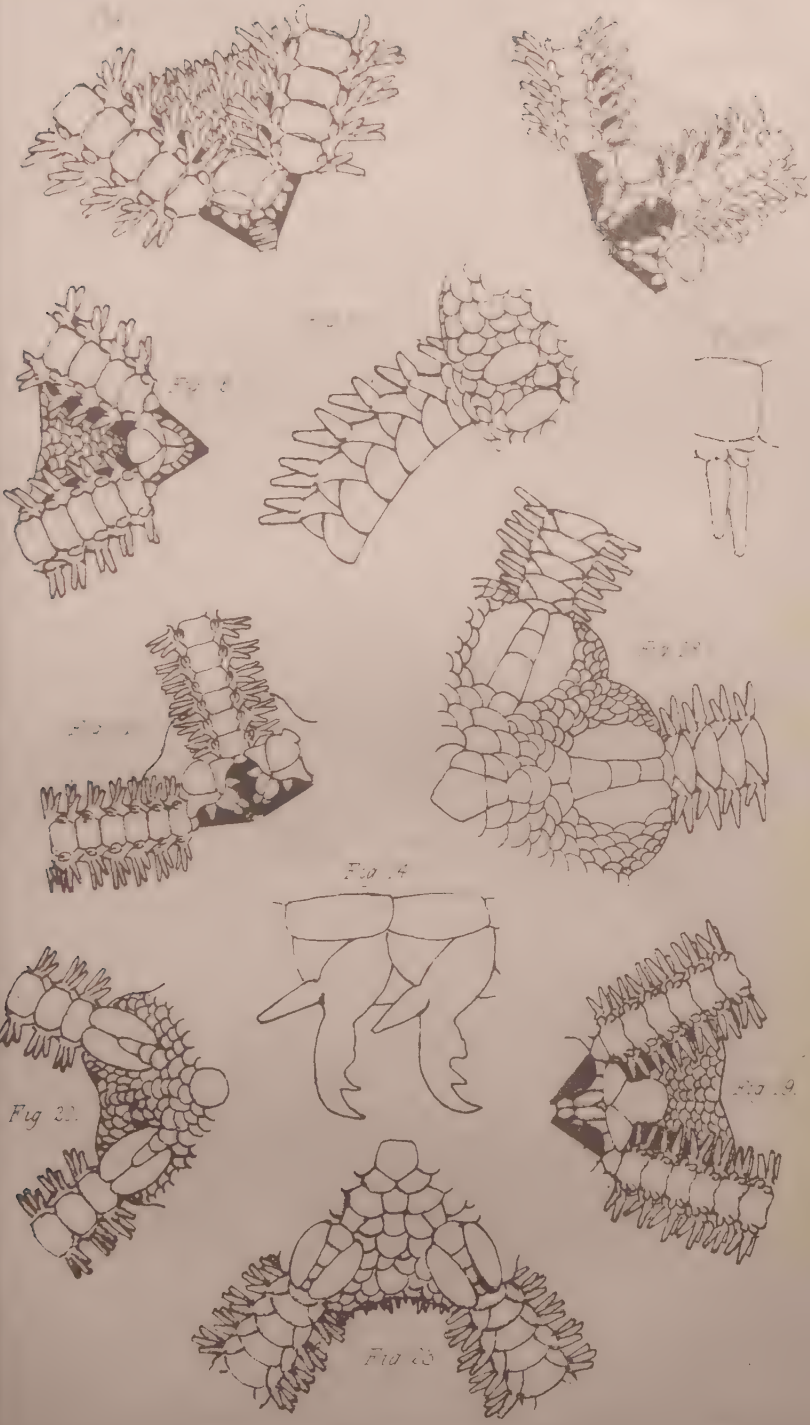
Ophionereis variegata is allied to the species *O. annulata* from Panama, but the arrangement of the side arm-plates, of the accessory plates, and of the mouth-papillæ differs. There is a manifest resemblance to *O. squamata*, Kinberg, from Honolulu; but the shape of the under arm-plates and the arrangement of the radial shields differs; and the resemblance is less to *O. crassispina*, Kinberg, from the same island.

Amphiura Lütkeni has small radial shields touching without, and the side mouth-shields are not joined within. There are four mouth-papillæ, two of which are spinous and long, and the inner pair large; there is but one tentacle-scale, and there are six spines near the disk, and four further out. This does not approach in form to any as yet described from the Pacific side of America.

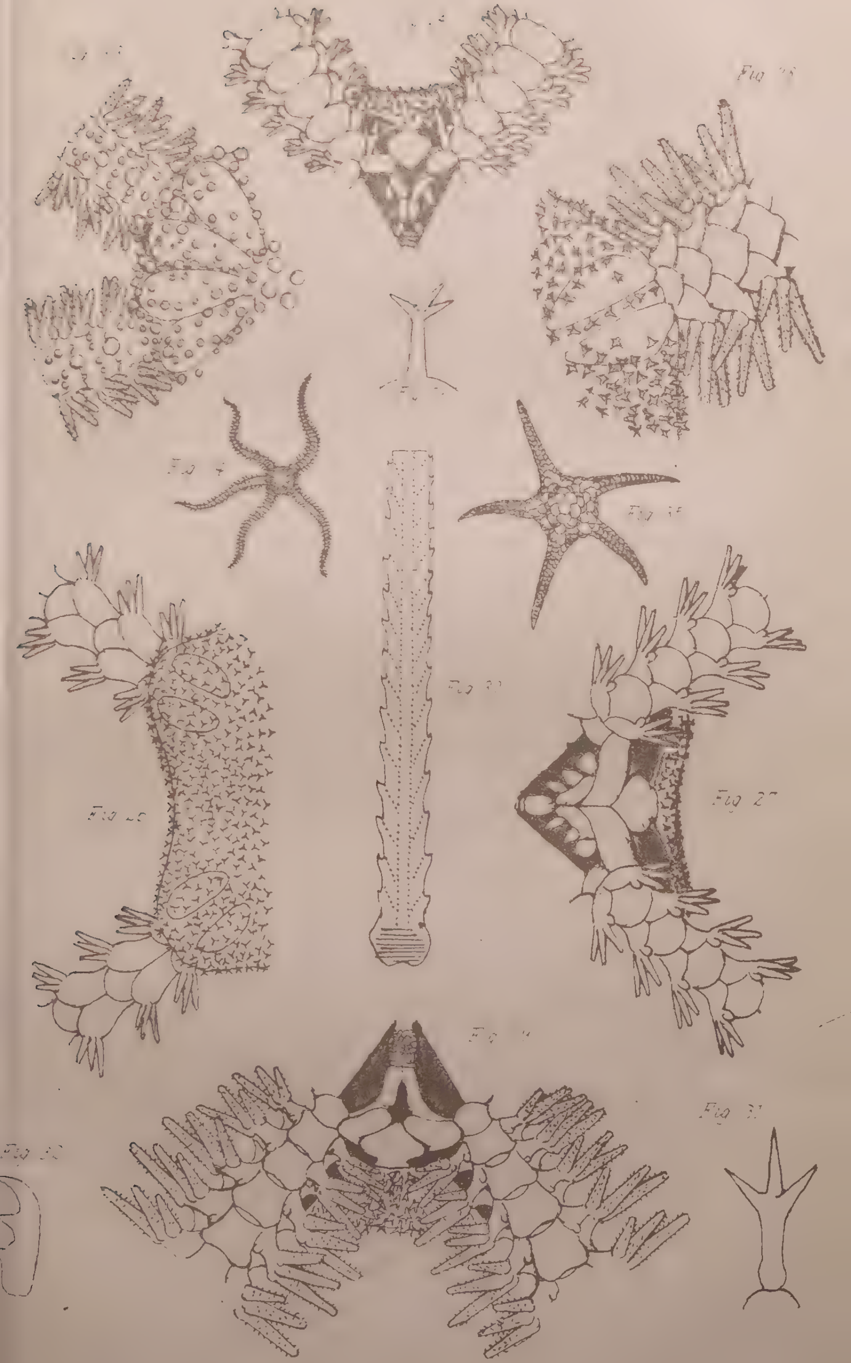
Amphiura koreæ has an oral arrangement of mouth-papillæ, jaws, and side mouth-shields remarkably like that of *A. squamata*, Sars, from the Atlantic and the eastern coast of the United States; but the radial shields differ, and the mouth-shields also; the arms also differ in length. Lyman states that there is a close resemblance between *A. squamata* and *A. tenera*, Lütken, from the West Indies, and *A. pugetana* from California. It is interesting to find this affinity prolonged still further west, in the form of the short-armed species under consideration.

The genus *Hemipholis* of Agassiz contains *Amphiuræ* with the disk naked below; but to this evident generic attribute he added some which are not of generic value, such as limiting the arm-spines to three and the mouth-papillæ to two. In *Hemipholis microdiscus* the two mouth-papillæ near the side mouth-shields are evident enough, but there are two more under the true teeth; moreover there are four spines.





Berjeau lith | OPHIURIDEA FROM KOREAN SEA | Fitch imp



Ophiactis sexradia, Grube, the *O. Reinhardtii* figured by Lütken, is evidently represented in the Korean fauna; and its range is enormous between America and Africa.

Ophiactis affinis so closely resembles an Amphiuran, that were it not for the spines on the margin and on the disk below, the propriety of making this spination any thing more than of specific value may well be doubted. It belongs to a group allied to *O. simplex*, Lütk., and *O. Mülleri*, Lütk., the one from Panama and the other from the West Indies.

The species of *Ophiacantha* is remarkable for the development of the side arm-plates, the nodular condition of the arm, and the small spines. It is a very distinct type.

The *Ophiothrix* is very variable, and belongs to the section with numerous glassy toothed spines, hooks with two claws, and an oval of numerous tooth-papillæ, numbering nearly twenty. Stumps bifid or trifid.

Finally, the *Ophiothela*, closely allied to *O. isidicola*, differs principally in the ornamentation of the disk.

DESCRIPTION OF THE PLATES.

Plate IX.

Fig. 1. *Ophioglypha Forbesi*, nobis, from above, ×8.
2. „ „ „ from below, ×8.
3. „ „ „ last lower arm-plates, ×8.
4. *Ophioglypha striata*, nobis, from above, ×8.
5. „ „ „ side of arm, ×8.
5*a*. „ „ „ serrature of side arm-plates, more magnified.
6. *Ophioglypha sculpta*, nobis, from above, ×8.
7. „ „ „ from below, ×8.
8. „ „ „ upper arm-plate, ×8.
9. *Ophioglypha Sladeni*, nobis, from above, ×8.
10. „ „ „ from below, ×8.
11. „ „ „ side of arm showing extra spines, ×8.
12. *Ophiolepis mirabilis*, nobis, from above, ×8.

Plate X.

13. *Ophiolepis mirabilis*, nobis, from below, ×8.
14. „ „ „ side arm-hooks, highly magnified.
15. *Ophionereis variegata*, nobis, oblique view, part of arm and disk, ×8.
16. „ „ „ from below, ×8.
17. *Amphiura Lütkeni*, nobis, oral structures, ×8.
18. *Amphiura koreæ*, nobis, from above, ×8.
19. „ „ „ oral structures, ×8.
20. *Hemipholis microdiscus*, nobis, from above, ×8.
21. „ „ „ from below, ×8.

Fig. 22. *Hemipholis microdiscus*, nobis, spines and tentacle-scales of arm, highly magnified.
23. *Ophiactis affinis*, nobis, from above, ×8.

PLATE XI.

24. *Ophiactis affinis*, nobis, from below, ×8.
25. *Ophiacantha Dallasii*, nobis, thorns of the disk, magnified.
26. „ „ „ from above, × 8.
27. „ „ „ from below, ×8.
28. *Ophiothrix koreana*, nobis, from above, ×8.
29. „ „ „ from below, ×8.
30. „ „ „ spine, highly magnified.
31. „ „ „ stump from the disk, highly magnified.
32. „ „ „ arm hook, highly magnified.
33. *Ophiothela Verrilli*, nobis, from above, ×8.
34. *Hemipholis microdiscus*, nobis, nat. size.
35. *Ophioglypha sculpta*, nobis, nat. size.

Descriptions of New Hemiptera. (I.)

By F. BUCHANAN WHITE, M.D., F.L.S.

[Read November 7, 1878.]

THE majority of the insects herein (and probably hereafter) to be described, were taken by my friend Professor J. W. H. Trail during his fruitful exploration of the Amazon region, in 1873–1875; and his localities refer to the country drained by that river and its tributaries. The types of all the species mentioned are in my collection. The subjoined tabular list of two new genera and seventeen new species comprises what is contained in this paper.

Paryphes pontifex.	Velia vivida.
Fibrenus bullatus.	—— virgata.
Largus lentus.	Neovelia Traillii.
Ischnodemus inambitiosus.	Microvelia mimula.
Pamera pagana.	Hydrobates regulus.
Lethæus lepidus.	Limogonus ? lotus.
Helenus hesiformis.	—— ? lubricus.
Acanthocheila abducta.	Pelocoris procurrens.
Hydrometra metator.	

COREIDÆ.

1. PARYPHES (SUNDARUS) PONTIFEX, n. sp. Supra et subtus cum antennis pedibusque æneo-viridis; lobo postico pronoti scutelloque croceis; hemelytris atris opacis, corii marginibus angustis costali apicalique, et commissura clavi flavescentibus; membrana nigro-brunnea;

rostro tarsisque nigris. Lobo postico pronoti utrimque in alas magnas rotundatas sursum vergentes dilatato. ♂ long. 18, lat. 5 millim.

Hab. Brasiliam borealem. (Lago cerrado, Rio Jurua, Oct. 30, 1874, *J. W. H. Trail.*)

Allied to *Paryphes regalis*, Westw., and *P. flavicollis*, Sign., but differing in coloration, shape of the pronotum, &c.

Lygæidæ.

2. Fibrenus bullatus, n. sp. Obscure castaneo-brunneus opacus, capite et margine antico pronoti ochraceo-hirsutis; pronoti marginibus lateralibus et postico flavis, linea longitudinali centrali castanea; corii marginis antici dimidio basali, margine apicali (angulo intimo excepto), necnon linea prope suturam clavi flavo-albidis; antennis, rostro, tibiis, tarsis membranaque nigris; marginibus posticis segmentorum ventris (quinto excepto), et signaturis segmentorum genitalium flavo-albidis. Pronoti lobo antico, præcipue in mare, convexo-prominulo, lævi; lobo postico, scutello hemelytrisque punctulatis; femoribus omnibus, præsertim anticis, subtus pone medium spinis nonnullis armatis. ♂ long. 9, lat. 3 millim.

Hab. Brasiliam borealem. (Manaos, 1874, *J. W. H. Trail.*)

3. Largus lentus, n. sp. Rufo-flavescens, maculis anticis et margine postico thoracis, necnon bucculis, antennis ad basin, maculisque exterioribus acetabulorum pallidioribus; pronoto antice et scutello ad basin obscurioribus; capite (tuberculis antenniferis et linea abbreviata inter oculos exceptis), antennis pedibusque nigris; sternis fusco-brunneis; parte basali metastethii et ventre testaceis, hujus limbo laterali et marginibus basalibus segmentorum in medio brunneis, lineolis longitudinalibus centralibus ad basin segmentorum nigris; pronoto fusco-punctato margine postico late brevi; scutello crebrius fusco-punctato; hemelytris remotius fusco-punctulatis, limbo exteriore subimpunctato; membrana hyalina; femoribus anticis subtus apicem versus spinis tribus armatis. ♀ long. 14, lat. 6 millim.

Hab. Brasiliam borealem. (Urubu Caxoeira, Rio Jurua, Nov. 6, 1874, *J. W. H. Trail.*)

It is with some hesitation that I bring forward this species as distinct from the variable *Largus humilis*, Drury. The hemelytra, however, are much more sparingly punctate, the front margin being almost impunctate, which (with the coloration unlike that of the various described varieties of *L. humilis*) seems to justify its specific separation.

Note.—The word "testaceous" seems to be rather indefinite in the meaning attached to it by various authors. By some a

reddish colour like that of red pottery is meant, by others an ochraceous yellow, with a slight brown tinge like sunburnt bricks, or "terra cotta." The latter is, I think, the correct interpretation of the term; and in that sense I use the word.

4. Ischnodemus inambitiosus, n. sp. Niger, sericeus, opacus, capitis vertice, lobo postico pronoti, abdomine pedibusque subnitidis; hemelytris pallido-ochraceis, clavi basi et margine interiore late, corii apice latissime, margine apicali, angulo interiore, et suturæ clavalis parte tertia apicali, necnon macula longa ovali (discum membranæ implente et extus apicem versus corii sinuata) nigris; femorum apicibus imis, tibiis, tarsis, et antennarum articulorum 3 basalium apicibus plus minus flavido-brunneis; rostro, tibiis anticis, tibiis ceteris ad apicem, et tarsorum articulo tertio obscurioribus; abdominis lateribus nigris; ventre ad basin ferrugineo. Hemelytris abdomine maxime brevioribus, rostro metasterni medium attingente. ♂ long. 6, lat. 1 millim.

Hab. Brasiliam borealem. (Camaná, Rio Javary, Dec. 6, 1874, *J. W. H. Trail.*)

Allied, but not very closely, to *Ischnodemus tibialis*, Stål.

5. Pamera pagana, n. sp. Subelongata, nigra, pallido-pilosula, parce punctata; antennis, rostro pedibusque testaceo-flavis, illarum articulo apicali fusco ante medium late albido-annulato; capitis clypeo et tuberculis antenniferis, pronoti collo antico et lobo postico brunneo-castaneis, hoc nigro-maculato; hemelytris sordide testaceo-flavis, clavo corioque fusco-punctatis; corii fascia pone medium irregulariter fracta, apice margineque apicali brunneo-fuscis; membrana sordide flavo-albida, inter nervos fusco-notata; tarsis ad apicem fuscis. ♂ long. 5, lat. $1\frac{1}{2}$ millim.

Hab. Brasiliam borealem. (Rio Solimoes, Nov. 13, 1874, *J. W. H. Trail.*)

Closely allied to *Pamera bilobata*, Say; but apparently distinct by its smaller stature, differently coloured antennæ and rostrum, the latter being also rather longer, by the coloration and especially the punctuation of the hemelytra, &c.

6. Lethæus lepidus, n. sp. Oblongus, nigro-piceus, rude punctatus; pronoti disco et angulis posticis maculis parvis, scutelloque lineis tribus abbreviatis brunneo-flavis notatis; hemelytris irregulariter pallido-venosis, et maculis, una basali, altera intus medium versus necnon duabus extus prope apicem, flavo-albidis notatis; membrana dilute fusca dilutius venosa; antennis brunneis; pedibus pallido-flavo-brunneis. Femoribus anticis subtus prope apicem spinis 4 parvis, et cum tibiis omnibus spinulis setiformibus nonnullis armatis. ♀ long. 6, lat. $2\frac{1}{4}$ millim.

Hab. Brasiliam borealem. (Lower course of the Rio Jurua, Nov. 12, 1874, *J. W. H. Trail.*)

Allied to *Lethæus pallidinervis*, Stål, but, besides the darker colour, differs in having the anterior femora, which in that species are unarmed, furnished with four small teeth towards the apex.

Aradidæ.

Helenus, n. g.

Corpus oblongum, retrorsum sensim dilatatum, supra cum antennis pedibusque valde villosum et setosum. *Caput* processu antico paullo producto, inerme, pone oculos sensim angustatum. *Antennæ* articulo primo maximam ad partem apicem capitis superante, articulis primo tertioque subæquilongis, articulo quarto quam dimidium tertii breviore. *Thorax* transversus, paullo ante medium transverse impressus, marginibus lateralibus emarginatis, margine basali ante scutellum sinuato. *Scutellum* triangulare, transversim rugosum, longitrorsus carinatum, marginibus elevatis. *Hemelytra* apicem abdominis fere attingentia, parte coriacea quam scutellum longiore, membrana venosa venis anastomosantibus. *Pedes* mediocres. *Venter* convexiusculus; spiraculis a marginibus lateralibus remotis, spiraculis segmenti quinti ad margines illos appropinquatis. Sternum et venter sulco longitudinali interrupto instructa.

In facies and structure closely allied to *Hesus*, Stål, but differing in, amongst other points, the shaggy pubescence, structure of the membrane, and the interruptedly sulcate sternum and venter, which latter character brings it into relations with the division *Aradina.* Name in honour of Professor James William Helenus Trail.

7. Helenus hesiformis, n. sp. Ferrugineus, villositate ochraceobrunnea vestitus; capite, antennarum articulo basali, femoribus, annulo apicem versus tibiarum, et segmentis genitalibus obscurioribus. ♂ long. 9, lat. pone medium $4\frac{1}{2}$ millim.

Hab. Brasiliam borealem. (Manaos, 1874, *J. W. H. Trail.*)

Tingitidæ.

8. Acanthocheila abducta, n. sp. Oblongo-ovata, nigra, opaca; hemelytrorum area costali necnon partibus totis pone abdomen fere vitreis, nigro-venosis; area costali fascia transversa picea abdominis apicem versus notata, et illic multo subtilius et irregulariter reticulata. ♀ long. 5, lat. 3 millim.

Hab. Brasiliam borealem. (Fonteboa, Oct. 13, 1874, *J. W. H. Trail.*)

The antennæ being broken, I cannot say whether all the joints are black.

HYDROMETRIDÆ.

9. HYDROMETRA METATOR, n. sp. Aptera, brunnea, opaca; antennarum articuli primi dimidio apicali, secundi apice et articulis 2 apicalibus (tertio ad basin excepto), rostro apice, femorum et tibiarum apicibus, necnon tarsis nigris. Capitis parte anteoculari quam pars postocularis duplo longiore; antennis gracillimis corporis æquilongis. ♂ long. 18, lat. 1 millim.

Hab. Brasiliam borealem. (Uruçaca, Rio Jurua, Nov. 1, 1874, *J. W. H. Trail.*)

The genus (which is the same as *Limnobates* of some authors) has not before, I think, been recorded from S. America.

VELIIDÆ.

10. VELIA VIVIDA, n. sp. Aptera, nigra, pubescentia nigra brevissima et capillis longioribus brunneis vestita; pronoti margine antico macula fulva (macula majore triangulari argenteo-sericea obtecta et fere occulta) utrimque notata; abdominis dorsi segmentis 2 basalibus utrimque argenteo-maculatis; sterni lateribus ventreque argenteo-sericeis; coxis, trochanteribus, femoribus anticis basin versus, connexivo et ventre ad medium testaceo-brunneis; antennis fusco-brunneis; pedibus rostroque brunneis, illis subtus pallidioribus. Antennis longis gracilibus, articulis primo secundoque subæquilongis, quarto quam secundus breviore, quam quintus longiore; pronoto longitrorsus carinato, angulis posticis tuberculo acuto extrorsum retrorsumque vergente instructis; femoribus posticis pone medium subtus spinis 2 armatis. Long. $7\frac{1}{2}$, lat. $2\frac{1}{2}$ millim.

Hab. Nicaraguam.

11. VELIA VIRGATA, n. sp. Alata, fusco-brunnea, capillis concoloribus vestita; pronoti margine antico macula irregulari triangulari argenteo-sericea utrimque notato; lateribus sterni abdominisque argenteo-sericeis; antennis concoloribus articulo basali (apice excepto) pallidiore; pedibus testaceo-brunneis, femorum macula basin versus subtus annulisque 2 latis, tibiarum annulis 3, tarsorum articulis ad apicem brunneis; connexivo testaceo-brunneo brunneo-maculato. Antennis sublongis gracilibusque, pronoto maxime convexo-elevato longitrorsus carinato, angulis posticis tuberculo obtuso instructis. ♂ long. 5, lat. 1 millim.

Hab. Brasiliam borealem. (Igarapé da Caxoeira, near Manaos, June 4, 1874, "at light," *J. W. H. Trail.*)

Neovelia, n. g.

Corpus oblongum. *Caput* antice truncatum, deorsum modice productum. *Oculi* magni antrorsum convergentes sed haud approximati. *Antennæ* articulo primo valde curvato, quam secundus duplo longiore, secundo tertioque subæquilongis, quarto quam tertius paullo breviore. *Hemelytra* homogenea. *Pedes* mediocres, intermedii reliquis longiores; tarsis anticis biarticulatis, articulo primo minutissimo, articulo ultimo brevissimo, crasso, fusiformi ante medium biunguiculato; tarsis intermediis triarticulatis tibiis fere æquilongis, articulo primo minuto, articulis secundo tertioque æquilongis, ultimo fere ad basin fisso; pedibus posticis brevibus, tarsis uniarticulatis, tarsis anticis gracilioribus et paullo longioribus, articulo fusiformi, pone medium biunguiculatis; femoribus posticis incrassatis subtus pone medium serie spinarum armatis, tibiis posticis curvatis.

I am by no means sure that the hinder tarsi have not a very minute basal joint. The spines on the hinder femora gradually decrease in size, the first (*i. e.* the one nearest the middle of the femur) being the longest. The structure of the tarsi at once distinguishes *Neovelia* from *Microvelia* and other allied genera. Name from νέος and *velia*.

12. Neovelia Trailii, n. sp. Nigro-brunnea, pubescentia conferta concolori vestita, capite, antennis, pedibus, pronoto postice abdominisque lateribus parce nigro-setulosis; pronoto antice, prostethio, connexivo, ventre ad medium, antennarum articulo primo ad basin, coxis, trochanteribus, femorum anticorum macula et vitta subtus, femorum posticorum basi et spinis ad basin flavido-fulvis; pronoti carina centrali subelevata plus minus, præcipue antrorsum, rufo-fulva. ♂ long. 4, lat. 1½ millim.

Hab. Brasiliam borealem. (Manaos, August 1874, "at light," *J. W. H. Trail.*)

13. Microvelia mimula, n. sp. Nigra, pubescentia conferta brevissima cinerea vestita; capitis vertice vittula geminata longitudinali rufescente male definita notato; pronoto intra marginem anticum fascia angusta latera haud attingente rufo-flava; hemelytris fuscis maculis 8 albidis ornatis; connexivo, pedibus antennisque pallide testaceo-fulvis, articulis ad apicem plus minus fuscis. ♀ long. 2 millim.

Hab. Brasiliam borealem. (Manaos, August 1875, "at light," *J. W. H. Trail.*)

HYDROBATIDÆ.

14. HYDROBATES REGULUS, n. sp. Apterus, testaceo-rufus, sternis ventreque pallide brunneo-sericeis; thoracis linea longitudinali utrimque percurrente, abdominis dorso (linea media tenui excepta), linea utrimque prope latus ventris, antennarum articulo primo ad basin et apice imo, secundo ad apicem, tertio quartoque totis, rostro, oculis, femorum anticorum vitta infera, femorum posteriorum et tibiarum intermediarum apicibus imis, necnon tibiis posticis et tarsis omnibus fusco-brunneis. ♀ long. 20, lat. $2\frac{1}{2}$ millim.

Hab. Brasiliam borealem. (Labria, Rio Purus, Sept. 16, 1874, *J. W. H. Trail.*)

Differs from *Hydrobates erythropus*, Burm., both in size and colour. The apical angles of the connexivum of the sixth abdominal segment are also less produced.

15. LIMNOGONUS (?) LOTUS, n. sp. Brunneo-niger, nitidus, lævis, subtus sordide albido-sericeus, capitis marginibus anticis argenteo-sericeis; capitis lineolis 2 longitudinalibus obsoletissimis anterius posteriusque abbreviatis, linea transversa basali utrimque dilatata, colloque, pronoti macula pone marginem anticum sordide rufo-testaceis; marginibus angustis lateralibus pronoti læte, anterius obsoletius et sordide flavescentibus; lateribus prostethii et mesostethii, vittaque angusta metastethii et ventris prope margines laterales nigris; parte laterali nigra mesostethii linea abbreviata argenteo-sericea ornata; pedibus infuscatis ad apicem saturatioribus; acetabulis medium versus, trochanteribus et femoribus anticis ad basin pallido-testaceis, horum margine infero et macula postica pone medium, necnon tibiis ad apicem fuscis; antennis dilute brunneis, articulis primo secundoque ad apicem, tertio quartoque totis fusco-nigris. Antennis vix $\frac{2}{3}$ corporis æquilongis, articulo quarto quam secundus breviore, secundo $\frac{2}{3}$ primi æquilongo, tertio et quarto subæquilongis; rostro paullo pone marginem anticum prostethii productum; pronoto longitrorsus obsolete carinato, ad marginem anticum prostethii distincte constricto, lobo antico ad medium depresso, lobo postico leviter convexo, angulis posticis elevatis; femoribus anticis crassiusculis; femoribus intermediis $\frac{3}{4}$ corporis æquilongis; tibiis intermediis quam femora paullo brevioribus; hemelytris apicem abdominis paullo superantibus. ♂ ♀ long. 6–7, lat. 2–$2\frac{1}{2}$ millim.

Hab. Brasiliam borealem. (Manaos, 1874, *J. W. H. Trail.*)

The comparative length of the antennæ-joints and the length of the rostrum are not in accord with the characters of *Limnogonus* as constituted by Stål. Still this and the following species may find a place in that genus in the meantime.

16. Limnogonus (?) lubricus, n. sp. *Limnogono* (?) *loto* simillimus sed minor, pronoto vix constricto, lateribus corporis haud vel obsoletissime nigro notatis, femoribus anticis linea longitudinali postica vice maculæ fuscæ ornatis. Long. 5, lat. 1½ millim.

Hab. Brasiliam borealem. (Manaos, August 1875, "at light," *J. W. H. Trail.*)

Naucoridæ.

17. Pelocoris procurrens, n. sp. Pallide brunneo-testaceus, capitis postici et pronoti maculis nonnullis irregularibus, connexivi signaturis, femorum anticorum supra macula irregulari et posterius basin versus vittula brunneo-fuscis; capite pronotoque obsolete, hujus disco distinctius et transversim rugosis; pronoti marginibus lateralibus angustissime reflexis; hemelytris minutissime punctulatis. ♂ long. 5, lat. 3½ millim.

Hab. Brasiliam borealem. (Montealegre, 1873, *J. W. H. Trail.*)

Belongs to the same section of the genus as *binotulatus*, Stål; but is very much smaller and otherwise different.

The Anniversary Address of the President, Professor Allman, M.D., LL.D., F.R.S.

Recent Progress in our Knowledge of the Structure and Development of the Phylactolæmatous Polyzoa.

[Read May 24, 1878.]

Continuing to adopt the practice which I have hitherto regarded as the most useful—that of making the Addresses delivered at the Anniversary Meetings of the Society reports of the progress of discovery in certain departments of zoological research—I have this year chosen for my subject the structure and development of the Phylactolæmatous Polyzoa, making the report extend over a period which dates from the publication of my own early researches on this group*.

Unless we include among them the genus *Rhabdopleura*†, all the Phylactolæmata are inhabitants of fresh water. One of their

* A Monograph of the Freshwater Polyzoa. Published by the Ray Society, 1856.

† I do not believe that *Rhabdopleura* has any real claims for admission into the group of the Phylactolæmata. The characters which at first sight

most obvious peculiarities is the possession of an epistome, an organ somewhat resembling the epiglottis of a mammal, which springs from the lophophore or support of the tentacular crown at the anal side of the mouth, whose entrance it defends much in the same way that the epiglottis defends the glottis. With one exception—that afforded by *Fredericella*—the lophophore is in the form of a crescent.

Structure.

We owe to Hyatt a very valuable and well-illustrated memoir on the structure of the Phylactolæmatous Polyzoa*. The genera which form the subject of his observations include, with the exception of *Lophopus*, all those hitherto found in Europe†, as well as a new genus *Pectinatella*, which, so far as we yet know, is confined to the United States. He has studied the histological structure of the endocyst and of the alimentary canal, the distribution of the muscles and of the nervous system; and on all these points has added much to our previous knowledge of the group.

Nitsche has also published the results of a series of very careful and valuable researches on *Alcyonella fungosa*‡, which he takes as a representative of the Phylactolæmata. He does not appear

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would appear to justify these claims are its crescentic lophophore and the possession of a shield-like organ extended over the mouth, and having some resemblance to the epistome of a Phylactolæmatous polyzoon.

The crescentic lophophore, however, of *Rhabdopleura* is very different from that of the Phylactolæmata, the tentacles which it carries forming an interrupted series instead of a continuous row round the edges of the lophophore. The shield-like organ, moreover, as shown by its development, has a significance entirely different from that of a Phylactolæmatous epistome. It is in fact an independent zooid (person) intercalated into the life series of the animal.

The characters of *Rhabdopleura* are altogether so anomalous as to place it in a great primary section of the Polyzoa, at least equal in rank to those of Ectoprocta and Endoprocta—a section for which one of its most striking features, the possession of the great supraoral shield, would suggest the name of Aspidophora.

* Alpheus Hyatt. "Observations on Polyzoa, Suborder Phylactolæmata," Proceedings of the Essex Institute (United States), 1865, vol. iv.

† *Alcyonella* is referred to merely as a form of *Plumatella*.

‡ Nitsche. "Beiträge zur Anat. und Entwick. der Phylactolæmen, insbesondere von *Alcyonella fungosa*," Archiv für Anat., 1868.

to have been aware of the researches of Hyatt, made a short time previously; and though he has, to a certain extent, been anticipated by these, his memoir has all the value of independent investigation.

Nitsche's observations agree, on the whole, with those of Hyatt, but in some important points supplement them; and we thus, from the combined labours of the American and German zoologists, have attained to a very accurate and complete knowledge of the structure of the Phylactolæmatous Polyzoa. The following may be regarded as the most important results of these researches.

Structure of Endocyst.—In the endocyst three distinct layers may be demonstrated. These are (in succession from without inwards):—1, an outer cellular layer; 2, a muscular tunic; 3, a ciliated epithelium.

The outer cellular layer is composed of two different forms of cells. The cells composing the principal mass of this layer are prismatic where they enter into the proper body-walls, while in the tentacular sheath or invaginable portion of the body-wall they have become diminished in height and increased in width so as to assume the form of flat polygonal cells. In every case they show a manifest cell-membrane, and possess a large and distinct nucleolated nucleus. Hyatt makes the interesting observation that in the tentacular sheath these cells are eminently contractile, occasionally dilating to twice or thrice their normal size, and then suddenly contracting.

Imbedded among the polygonal cells we find those referable to the second form. These are roundish or oval, also with manifest membrane and with small parietal oval nucleus. Their contents, which in the living animal are clear and strongly refringent, become quickly and intensely coloured by carmine solution, while the polygonal cells are scarcely affected by the colouring-matter.

In the muscular tunic two distinct sets of fibres may be detected, an outer circular or transverse set, and an inner longitudinal set, both supported by a common delicate homogeneous foundation membrane. Both circular and longitudinal fibres are smooth, more or less flattened, contain a nucleus, and lie with their pointed ends wedged between each other.

The third and most internal layer of the endocyst is the ciliated epithelium. Nitsche has noticed that the cilia do not

uniformly cover this layer. On the tentacular sheath and on the under part of the body-wall they are disposed in separate groups, each of which is seated on a small elevation determined by the presence of a nucleus.

Structure of Alimentary Canal.—The histological structure of the alimentary canal is very similar to that of the endocyst. Its walls, for the greater part of their extent, are here also composed of three layers. The outer is an epithelial layer continuous with the epithelial or inner layer of the body-wall. It is, however, destitute of cilia, and is composed of flattened fusiform cells, containing a nucleus, but without any cell-membrane. At the blind end of the stomach it increases in thickness, and is here continued over the funiculus.

Next to the epithelium is a muscular layer composed of fibres supported by a transparent homogeneous foundation membrane. The fibres are flat bands pointed at each end, and having for the most part a longish nucleus in the middle. They run transversely round the alimentary canal, with the pointed ends of each wedged into the intervals of others. Nitsche has noticed in them a kind of striation, but has not satisfied himself that this depends on an essential structure of the fibre. The muscular fibres are absent on the extreme point of the stomach where this passes into the funiculus.

The most internal stratum of the alimentary canal consists in the stomach of a single layer of cells. Here this layer is thrown into longitudinal ridges, whose cells contain brown granules, which possibly indicate a hepatic function. The ridges have been shown by Nitsche to consist of certain cells of this layer which have become elongated, and are sometimes enlarged at their free extremities so as to present a club-shaped form*.

The inner layer of the rectum appears also to consist of a simple layer of cells. These are prismatic, and sit vertically on the muscular layer. Each is provided with a nucleus at its base; and as they are all of equal length, the longitudinal ridges of the stomach are here wanting.

In the œsophagus the cells which correspond to this layer present, according to Nitsche, a very remarkable condition. He describes them as being of long prismatic shape with the long

* This view is apparently the right one, and is a rectification of a somewhat different description of the longitudinal ridges given formerly by myself ('Monograph of the Freshwater Polyzoa').

axis perpendicular to the walls of the œsophagus. They have in their middle a large oval nucleus with clear strongly refringent nucleolus. The nucleus divides the cell into an inner half and a peripheral half. The peripheral half is clear, and has the appearance of being empty and closed at its inner end by the nucleus, while the inner half is filled with granular contents. The inner half, moreover, is provided with a special cell-membrane, while the peripheral half has no proper membrane. The peripheral portions thus appear to constitute a system of lacunæ in which the wall of one forms a part of the wall of that abutting on it, and which may be thus best compared with a honey-comb.

Lying on the free end of each of these œsophageal cells may be seen a small transparent vesicle, which at one time swells out into a sphere, at another contracts into a short ovoid. These vesicles seem to represent an internal epithelial layer of the œsophagus. Where the œsophagus slightly dilates towards the mouth, they are replaced by cells bearing long cilia, and here also the honey-comb-like lacunæ are absent.

Tentacles.—The walls of the tentacles are composed of three layers—an outer cellular layer, an inner epithelium, and an intermediate homogeneous membrane. Muscular fibres also enter into the composition of the tentacle; but these do not form, as in the body-walls and alimentary canals, a continuous layer. The homogeneous membrane forms the proper foundation-layer of the whole tentacular crown. It is in direct continuation with the homogeneous membrane of the muscular layer of the œsophagus and body-wall, and, like this, is easily coloured by carmine solution. It forms also the foundation-layer of the intertentacular membrane, and is continued beyond the free margin of this membrane along the opposed sides of the tentacles in the form of a ridge, which, however, in the living animal, is concealed beneath the outer cellular layer, beyond which it does not project.

The outer cellular layer of the tentacles is divided by this ridge into two distinct portions. That which lies behind the ridge is directly continued from the outer cellular layer of the body-wall which passes uninterruptedly from the tentacular sheath upon the back of the tentacles, where it presents the two elements already described, the polygonal cells and the round cells. This part of the cellular layer carries no cilia; but, on the other hand, fine, long, stiff bristles have been described by Nitsche as occur-

ring here along the middle line of the tentacle; these are arranged in groups of two or three at tolerably regular intervals.

While the outer cellular layer of the body-wall is thus carried over the back of the tentacles, their opposite or oral side is clothed by a continuation of the ciliated epithelium of the mouth. Besides the cilia thus continued from the mouth along the middle line of the oral side of the tentacles, there is a dense line of vibratile cilia along each of the opposed sides of the tentacles. On each side of the ciliated tract which runs along the middle of the oral face of the tentacle and between this tract and the lateral line of cilia is a non-ciliated area which, according to Nitsche, carries a series of long stiff bristles. These stand singly at regular distances from one another and tolerably close, thus differing from the bristles on the back of the tentacles, which are disposed in groups of two or three.

The inner epithelium extends from the cavity of the lophophore into that of the tentacle, and presents two strong ridges, one along each of the lateral sides of the tentacular lumen.

Special Muscles.—The investigation of specimens hardened in chromic acid shows in the interior of the tentacles two fasciculi composed each of two or three long fibres. These had been already noticed by Hyatt, and their existence is now confirmed by Nitsche. They run, one along the oral side, the other along the opposite side of the tentacle. Their fibres contain nuclei and are apparently muscular.

The same homogeneous membrane already so frequently referred to has been followed by Nitsche into the epistome, where it forms the foundation-layer of this organ. Hyatt describes three muscle-bands as entering into the structure of the epistome. I had already described the musculature of the epistome as consisting of a single strong fasciculus which acts as an elevator*. With this view the observations of Nitsche are entirely in accordance.

Under the name of "brachial contractors," Hyatt describes a series of previously unnoticed muscular bands situated within the arms of the lophophore, where they run transversely in their walls. These, by their contraction, act on the floor of the arms, drawing it up into folds.

He also, under the name of "lophophoric flexors," describes

* 'Monograph of the Freshwater Polyzoa.'

a pair of large muscles, one in each arm. These run from the oral region to the extremities of the arms, and serve to elevate their tips.

The two groups of muscles hitherto known as the "great retractors of the polypide" and the "rotators of the lophophore" are brought together by Nitsche under the designation of the "great motor muscles of the polypide." He so names them from a belief that when the polypide is completely retracted its extrusion may be initiated by the action of these muscles, though when it is only partially retracted the contraction of the body-wall may, by its pressure on the contained fluid, be of itself sufficient to bring about the evagination of the tentacular sheath and the protrusion of the polypide.

Nitsche further shows that the individual fibres of these muscles are each enveloped in a distinct sarcolemma, and are provided with a nucleolated nucleus, which lies between the proper muscle-substance and the sarcolemma. In quite young buds the muscle-fibres are found to be as yet short fusiform cells with parietal nucleus. Nitsche has never been able to see a true striation in the muscular fibre, but only a slight transverse wrinkling of the sarcolemma; while the breaking up of the fibrillæ into disks, which may be occasionally witnessed, takes place so irregularly, that he cannot regard it as indicating a normal structure.

The posterior parieto-vaginal muscles are described by Nitsche as continuous with the longitudinal fibres of the endocyst. They are not, like the other special longitudinal muscular bundles (such as the great motors of the polypide), simple structures consisting of a single histological element, but are composed (1) of a foundation-membrane formed by a prolongation of the homogeneous membrane of the tunica muscularis of the body-wall, (2) of muscular fibres which pass inwards in bundles from the longitudinal fibres of the body-wall, (3) of an epithelium by which each parieto-vaginal band is enveloped. The muscular fibres of these bands pass upwards on the tentacular sheath, and form its fine longitudinal musculature.

With this composite condition Nitsche contrasts the simple structure of the anterior parieto-vaginal muscles. These, moreover, are not, like the posterior, continued into the muscular layer of the body-wall. Each fibril of the anterior set is known to present a small swelling, which he has proved by treatment with chromic acid to be a true nucleus. He has also observed

that, on the places where these nuclei lie, the muscular fibre and nucleus are enveloped by a fine sarcolemma.

Nervous System.—Both Hyatt and Nitsche have made the nervous system of the Phylactolæmata a subject of careful study, and have considerably advanced our knowledge of it. The central nerve-mass is described by Hyatt as presenting a longitudinal depression which indicates a division into two lateral masses, each of which would form a ganglionic centre for the nerves going to its own side of the body. Nitsche has made a similar observation, which thus tends to confirm Dumortier's original view of the existence of two lateral ganglia in the central nerve-mass of *Lophopus*, though Hyatt has not succeeded in demonstrating the existence of an œsophageal collar.

A very delicate œsophageal collar has, on the other hand, been described by Nitsche, who makes an apt comparison of the central nerve-mass to a signet-ring with two long horns affixed to the right and left of the stone. The stone represents the ganglionic centre, the remainder of the ring the œsophageal collar, and the two horns are thick chords which pass into the arms of the lophophore.

The two ends of the ganglion, whose double nature may be inferred from the presence of a deep furrow on the surface which rests on the œsophagus, are continued laterally round the œsophagus, thus forming the œsophageal ring just referred to. This ring, however, is very thin and difficult to detect. The two chords which are sent off from the opposite side into the arms of the lophophore are much thicker.

The central mass is, according to Nitsche, surrounded by a firm envelope, which appears to be identical with the homogeneous membrane already so often mentioned. By means of this the ganglion is attached to the œsophagus, and the horns to the arms of the lophophore. The contents of the envelope consist of a finely granular mass in which very numerous nuclei are scattered, the nuclei preponderating over the finely granular matter both in the ganglion and in the horns. The œsophageal ring, on the other hand, shows an indistinct fibrous structure, and a similar structure is seen in the very delicate peripheral nerves which proceed from the ganglion and horns.

From the sides of the horns and from their points run a number of fine chords, each of which passes towards the inter-space between every two tentacles, then passes through the walls

of the lophophore, and divides into branches on the intertentacular membrane beneath the cellular layer; but no closer connexion of the nerves with the tentacles could be traced. Nitsche also believes that he has seen a fine filament pass from the anterior margin of the ganglion into the epistome, but cannot speak of this with certainty.

The central mass is stated by Hyatt to be contractile, and, as a result, mutable in form. It is difficult to reconcile this character with the properties of a true nervous centre, and one can scarcely help believing that Hyatt's account of it rests on some deceptive appearance.

Statoblasts.—Hyatt describes the statoblasts of *Pectinatella* as armed, like those of *Cristatella*, with spines; but he has not succeeded in detecting in the statoblasts of *Pectinatella* the ciliated membranous envelope which in *Cristatella* surrounds these bodies before their liberation. In *Pectinatella* they are detached from the funiculus before the appearance of the spines, and then lie loose in the body-cavity, where they remain until the death of the polypide and the decay of the upper part of the zoœcium affords them exit. They are then floated off, and remain during the winter in a quiescent state, and often imbedded in ice. The young polyzoon, which on the approach of spring protrudes from between the separating valves of the statoblast, has the whole of its free surface covered with vibratile cilia. By the aid of these it enjoys for some time a free-swimming existence, and finally disencumbers itself of the old valves of the statoblast, loses its cilia, and becomes fixed.

The peculiar statoblasts which are known to occur in several freshwater species, and which, instead of being free, are always found closely adherent to the walls of the zoœcium, are regarded by Hyatt as originating in these walls instead of being formed, like the free statoblasts, in the funiculus. He also states that the free statoblasts of *Fredericella*, though primarily formed, like those of other genera, in the funiculus, become subsequently attached to the walls of the zoœcium, where they resemble in all respects the true fixed statoblasts.

Development.

Development of the Bud.—Some very valuable contributions to our knowledge of the development of the Phylactolæmata have been made by Metschnikoff and by Nitsche.

Metschnikoff, in a short communication to the St. Petersburg Academy *, describes the eggs of *Alcyonella* as formed in the inner epithelial layer of the body-cavity, where they occur as simple cells combined into a mass so as to form an ovary. From this are detached the mature eggs with the germinal vesicle still apparent. These float about for a time in the body-cavity, and then enter into relation with a peculiar bud, which appears, in the form of an ordinary Polyzoon bud, on the walls of the body-cavity, into which it projects. He could not discover how the egg becomes first attached to this bud; but he has determined that it ultimately becomes included within it, the bud enveloping it in a duplicature which he compares to a decidua reflexa. In the sort of brood-capsule thus formed the egg undergoes total cleavage, and becomes changed into a heap of cells, which, after enlarging, forms a central cavity surrounded by a double layer of cells. This constitutes the cyst of the well-known *Alcyonella*-larva, within which two polypides subsequently make their appearance by budding. In this budding both laminæ of the cyst-walls participate. The outer lamina serves for the formation of the outer epithelium of the tentacles and the inner epithelium of the alimentary canal; while the central nervous system, which in the larva is very large, is also most probably derived from it. The inner lamina, on the other hand, forms all the muscles of the body, as well as the genitalia and the inner epithelium of the body-cavity.

Nitsche had arrived at nearly the same conclusion regarding the part taken by the two germinal laminæ in the formation of the tissues of the polypide in the marine polyzoon *Flustra membranacea* †; and he further ‡ confirms Metschnikoff's remarkable observation regarding the reception of the eggs of *Alcyonella* into a brood-capsule formed as a bud from the walls of the body-cavity. He sees in this last observation a solution of the question regarding the escape of the larvæ from the body-cavity of the parent, though no orifice which could serve as exit had been hitherto detected. He has convinced himself that the brood-sac of *Alcyonella*, which, quite like the polypide-buds, arises near the invagination-orifice of the parent zoœcium, finally opens at its anterior end, where it is connected with the endocyst in the same way as the tentacular sheath of a young polypide. The larva

* Bull. de l'Acad. de St. Pétersbourg, xv. 1871, p. 507.

† Zeitschr. f. wiss. Zool. Bd. xxi. p. 457. ‡ *Ibid.* Bd. xxii.

which had been included within it is thus liberated, and enters on its free life in the surrounding water.

Nitsche compares this brood-capsule to the oœcium or ovicell of the marine Polyzoa, which is formed as an external bud on the body-wall, and into which the fecundated egg passes in order to escape finally into the sea.

It appeared to me some years ago, when engaged in examining the larvæ of *Alcyonella*, that these were set free into the body-cavity of the parent, whence they subsequently gained exit by the destruction of the tissues. Nitsche believes that in this case they obtained access to the body-cavity by accidental rupture of the brood-capsule. It is possible that Nitsche may be right in this; at all events, without an opportunity of controlling, by further examination, my original observation, I do not desire to insist on its accuracy.

In a subsequent memoir * Nitsche traces the formation of the bud in *Alcyonella* and points out in detail the parts which the endoderm and ectoderm (the two germinal layers) take in the formation of the tissues and organs. He had already shown that the wall of the cystid or zoœcium of *Alcyonella* consists of three different layers besides the externally excreted ectocyst or cuticula. These are an outer epithelium, an inner epithelium, and a tunica muscularis lying between the two and consisting of a structureless supporting membrane on which lie transverse and longitudinal muscular fibres.

The first indication of the polypide-bud shows itself as a sac-like bulging inwards of the cystid wall. In this bulging the tunica muscularis, however, takes no part, but seems to be absorbed at the spot where the bud occurs. The polypide-bud consists therefore at this stage of a two-layered cellular sac, whose inner layer, bounding its central cavity, passes continuously into the outer epithelium of the cystid wall, while the outer layer is continuous with the inner epithelium of the cystid.

Nitsche follows Metschnikoff in regarding the outer epithelium of the cystid as the outer germinal layer or ectoderm, the inner epithelium as the inner germinal layer or endoderm; and if we further regard the tunica muscularis as a middle germinal layer or mesoderm, we may view the young polypide-bud as com-

* "Untersuchungen über die Knospung der Süsswasserbryozoen, insbesondere der *Alcyonella*," Sitzungsberichte der naturforschenden Gesellschaft zu Leipzig, 1874.

posed of two concentric cellular layers—the internal derived from the ectoderm, the external from the endoderm of the cystid, while the mesoderm of the cystid takes no part in the formation of the bud. The point where the cystid walls have become invaginated to form the bud corresponds in the completed polypide to the spot at which the tentacular sheath passes into the wall of the cystid; while the blind end of the sac corresponds to the blind end of the future polypide stomach, that from which at a later period the funiculus proceeds—an organ, however, whose genesis Nitsche has not succeeded in tracing.

Folds and secondary introversions of this two-layered cellular sac give to the young polypide its definitive form. First, two lateral introversions of the posterior part of the sac grow towards one another, and finally meeting convert this part into a bent tube, each of whose arms opens into the still unchanged anterior part. The bent tube becomes the alimentary canal, and the two openings by which its lumen communicates with that of the anterior part of the sac are the oral and anal orifices of the future polypide; while the anterior unchanged portion of the sac is to become the tentacular sheath.

The alimentary canal and tentacular sheath thus sketched out consist each of two cellular layers. The inner epithelium of the alimentary canal is derived from the ectoderm of the cystid, while the outer is derived from the endoderm. The two layers of the tentacular sheath have a precisely similar derivation.

There next occurs, right and left of the oral orifice, a conical introversion of the walls of the alimentary canal. There are thus formed two hollow cones, whose lumen is in each accessible from the body-cavity of the cystid by a wide opening. These are the foundation of the two arms of the crescentic lophophore. In the further course of the development they become united by a ridge, which runs round the abanal margin of the mouth. This ridge is formed by an infolding of the two layers of the bud, and constitutes the foundation of the abanal or middle portion of the lophophore. The lophophore is thus in its essential features sketched out, and from this the tentacles arise as hollow protrusions of the lophophore walls. Each tentacle thus represents a short cæcal tube which projects free into the cavity of the original cellular sac of the bud, and has its lumen in connexion with the cavity of the cystid, never with that of the polypide. The tentacles arise nearly simultaneously from the entire margin of the

lophophore, with the exception of the two opposed margins of the arms, where they sprout first after the polypide can protrude itself from its cystid. Nitsche compares the arms of the lophophore to two great primary tentacles, from which the secondary (or definitive) tentacles sprout. From this account of the orifice of the tentacles it is obvious that their outer epithelium, which afterwards becomes ciliated, is derived from the ectoderm of the cystid, which corresponds to the inner layer of the bud; while their inner epithelium is derived from the endoderm of the cystid, the outer layer of the bud.

Already, long before these last-mentioned occurrences take place, the nervous ganglion has made its appearance. At the margin of the mouth, between the bases of the arms of the lophophore, there may be seen an introversion of the two cellular layers. This is so situated that its shallow lumen communicates with the cavity of the tentacular sheath. Its direction is thus the reverse of that of every introversion hitherto described as occurring in the development of the bud; for none of these open into any part of the cavity of the bud, but, on the contrary, have their lumen always in communication with the cavity of the cystid. The margins of the shallow introversion thus formed now grow together, in quite the same way as the margins of the medullary groove in the vertebrate embryo. In this way a button-like vesicle, composed of the two cellular layers of the bud, is pushed out from the walls of that part of the bud which is to become the pharynx of the polypid. It is the first sketch of the nervous ganglion, and at this stage is relatively very large. From its mode of formation, it is obvious that its internal proper nervous substance proceeds from the internal layer of the bud, which is derived from the ectoderm of the cystid; while its envelope is a continuation of the external layer of the bud, the endoderm of the cystid.

The phenomena here described are in accordance with the general law that the central nervous system is always derived from the ectoderm of the embryo; but, as Nitsche suggests, we must not in the present instance lose sight of the fact that the inner layer of the bud, though arising from the ectoderm of the cystid, has fundamentally different relations from those of an ordinary ectoderm, for there proceeds from it, at the same time with the nervous substance of the ganglion, the entire epithelial lining of the intestinal tract.

As yet no trace of muscular fibres can be detected in any part of the tentacular sheath or of the alimentary canal. These are formed at a later period; but Nitsche has not been able to determine from which of the two layers they are derived. The fibres of the retractors and of the parieto-vaginal muscles arise each out of a single cell of the endoderm—that is, of the outer layer of the polypide-bud close to the spot where this is connected with the wall of the cystid.

Formation of the Statoblast.—Nitsche has further paid great attention to the statoblasts of *Alcyonella*, and has given a very complete account of their mode of formation, which he shows to be a curious and complicated process*.

These bodies, as is well known, consist of two parts,—a lenticular disk enclosed in a chitinous envelope, and composed of the material from which a young individual is to be developed; and a chitinous ring running round the edges of the disk, composed of air-filled chambers and acting as a float.

The statoblasts arise from a sausage-shaped body, which is formed immediately below the outer epithelium of the funiculus, and is composed of nucleolated nuclei with a small quantity of intervening protoplasm. From this are constricted off one after another small heaps of nuclei. These heaps continue to lie between the body of the funiculus and its epithelial layer. Each of them represents a statoblast, and soon shows a division into two halves by means of an equatorial furrow, so that it assumes an appearance very like that of the vitellus of an ovum after its first segmentation. In the next place that half which lies furthest from the funiculus becomes excavated by a central cavity, the nuclei which compose it arranging themselves in a single layer on its periphery. This excavated half is destined for the formation of the chitinous envelope with the float-ring, while the other affords the material out of which the young animal is to be developed. The former is termed by Nitsche the cystogenous layer, the latter the formative mass.

Protoplasm now collects round the nuclei, forming the walls of the cystogenous layer, and converts them into true cells, which become elongated prismatic, and assume the form of a cylinder epithelium. An increase of protoplasm also occurs round the nuclei of the formative mass.

* Archiv für Anat. 1868.

The young statoblast now assumes an oval lenticular form, while the cavity of the cystogenous layer disappears by the approximation of its walls; and this layer now lies on the free surface of the formative mass in the form of an oval plate composed of two cellular layers, which pass into one another at their margins.

The cystogenous layer next extends itself at its margins, and gradually grows round the formative mass nearly in the same way that the fold of the amnion grows round the embryo.

At the same time there appears, between the two cellular layers of the cystogenous portion, a strongly refringent membrane. This is the foundation of the chitinous envelope of the disk, and is apparently a secretion from the cells of the outer layer.

The formative mass has in the mean time become differentiated into long fusiform cells, filled with strongly refringent granules and without any apparent nucleus.

The cystogenous layer now continues to grow round the disk, depositing as it proceeds the chitinous secretion between its two layers, and its margins have begun to approach one another at the opposite side of the disk. The inner layer has, however, become less distinct, a condition which is only a precursor of its complete disappearance; while the cells composing the outer layer at that part where it bends round the sharp edge of the disk have become very much elongated, and the outermost ones, here gliding away from the disk, have arranged themselves in two series, an upper corresponding to the upper side of the disk, and a lower corresponding to its lower side. The cells of each of these series impinge by their bases on the bases of those of the other in a plane which corresponds to an extension of the sharp edge of the disk.

A remarkable phenomenon now shows itself in these elongated cells. They begin to secrete chitin, not only from their bases as they have all along done, like all the cells of the outer layer, but from their sides, so that a chitinous secretion is thus deposited in the intercellular spaces.

The secretion from their bases forms a thin double lamella, which runs round the margin of the disk in the form of an extension of its sharp edge; while the secretion from the sides of the cells forms, both on the upper and lower sides of this lamella and on the adjacent parts of the disk, a series of short chitinous tubes,

hexagonal in transverse section, and closely adherent to one another by their sides. These tubes form the foundation of the chitinous float-ring; they are, however, still open on their summits, and are each filled by the soft cell which acted as its matrix.

The chitinous envelope of the disk has now considerably increased in thickness, and along with the outer stratum of the cystogenous layer has extended still further towards the middle of the underside of the statoblast, while the inner stratum of the cystogenous layer has entirely disappeared.

The closure of the chitinous envelope, however, in the middle of the underside of the disk is not yet completed, and there still remains at this point a round hole through which part of the soft contents of the disk protrude. As the hole grows gradually smaller by the advancing chitin-deposit, the protruding mass becomes constricted off, and at last the disk becomes completely enclosed in its chitinous envelope.

Nearly up to the point of the complete closure of the chitinous envelope the chitin had been laid down by new cells which are being constantly formed on the advancing margin of the cystogenous layer. The final disappearance of the central aperture, however, is effected by the cells, which already lie round its circumference, bending over the aperture, cupola-like, and depositing the chitin from their bases.

The stage is now attained in the development of the statoblast when the disk is completely enclosed in its chitinous envelope and the chambers of the float-ring are laid down. These chambers, however, are still open on their summits, and are filled with their formative cells. The whole of these contents now withdraw towards the peripheric or open ends of the chambers, so that these are left empty, and the cells which had filled them now hang, in the form of small nucleated lumps of protoplasm, on the epithelial layer of the statoblast.

These little protoplasmic masses become gradually broader, press close to one another, and form with the remaining cells of the cystogenous layer a continuous stratum all round the statoblast. This stratum now begins to secrete chitin from its entire inner surface; and by the chitinous deposit thus uniformly laid down over the surface of the statoblast, the chambers of the float-ring are closed above and the chitinous envelope of the disk thickened. The fine tubercular sculpture which characterizes the

completed statoblast is now distinctly visible on the surface of the disk, and exactly corresponds to the form of the secreting matrix.

It is thus evident that the cell-like chambers which compose the float-ring are not true cells, but a chitinous deposit moulded on the surface of cells. The statoblast is now complete, the soft cellular layer which had surrounded it gradually disappears, the epithelial layer which had held it to the funiculus also disappears, and the statoblast falls into the body-cavity of the animal, where it remains until the destruction of the latter sets it free.

New Forms.

Besides several new species belonging to genera already described, a new generic form from North America has been added by Hyatt to the Phylactolæmata. He names it *Pectinatella*. Its nearest ally would seem to be *Lophopus*, from which it differs by its gelatinous ectocyst being confined to the base, where it forms a broad disk, often several inches thick, and common to numerous colonies. The naked endocyst is divided into lobiform branches, in which the zoœcia with their polypides are immersed. The protrusion of the polypides is scarcely limited by any permanently invaginated fold of the endocyst, as in *Lophopus* and other genera, the tentacular sheath in *Pectinatella* rolling out nearly to its full length. This is described by Hyatt as resembling, in its completely evaginated state, "a column supported by a simple ovolo and fillet." The statoblasts are provided with marginal spines, as in *Cristatella*.

Only one species is known, *P. magnifica*, Hyatt. This occurs abundantly in shallow water during the months of July and August; but as autumn advances it is found attached to logs in deep cold water, at a depth which in some cases reaches 15 or 20 feet. "The tropical aspect and luxuriant growth of the clinging masses, frequently several feet in diameter, investing the summits of submerged stumps &c., are unequalled among the freshwater, or even among the marine, forms of our climate."—*Hyatt.*

MOLLUSCA OF H.M.S. 'CHALLENGER' EXPEDITION.

I. Preliminary Report to Prof. Sir C. WYVILLE THOMSON, F.R.S., Director of the Civilian Scientific Staff, on the Mollusca dredged during the Exploring Voyage. By the Rev. ROBERT BOOG WATSON, B.A., F.R.S.E., F.L.S., F.G.S.

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[Read November 21, 1878.]

To begin at once the publication of the Mollusca of the 'Challenger,' however undesirable in many ways, is a necessity if the whole is to be overtaken in reasonable time.

The mass of material which has come into my hands is enormous.

In the end of 1876 (Nov. 17) there were sent me two large boxes of shells containing very many smaller ones, each labelled with note of locality whence their contents came; and in the beginning of 1878 (Jan. 17) of additional material there came into my hands 48 boxes, chiefly small, of shells, 131 bottles, large and small, and 45 tubes containing the shells with the animals preserved in spirit, and 36 bottles of miscellaneous dredgings, some dry, some in spirit.

My first duty was to arrange all the distinct shells, separating the species, putting each species from each locality in a box by itself, and marking on each the name of the genus and of the species, where possible, with note of the station whence it came and other information likely to be useful. The admirable accuracy with which the material from each locality had been kept apart and labelled made this possible.

Then under each station a catalogue of the genera and species belonging to it had to be drawn out, with general index to the whole.

Having thus cleared off the more manageable part of the mass, the dry miscellaneous dredgings had next to be sifted through sieves, and the shells, most of them, of course, very small, to be picked out and then sorted, as had been done with the others. Of this a good deal is still imperfectly done.

Finally, the wet miscellaneous dredgings, *i. e.* those preserved in spirit, have to be similarly treated. This is a very much more troublesome task, and has not yet been fully done. Further, I am still in arrears with the individual specimens preserved

in spirit, the handling of which, with the sorting into bottles, and still more the examination and even partial dissection of the animals, require very much more time. Some 300 of these have, however, even already been sorted out.

In all, over 2000 separate lots, including from 1200 to 1500 distinct species, have been gone over, separated, put into boxes or bottles, labelled, catalogued, and indexed. There yet remains, indeed, a very great deal to do; but through it I do, to some extent, see my way.

Simultaneously with all this, authorities have been consulted, and types in the British Museum and elsewhere, as opportunity offered, have been examined, to determine which of the species under my charge are already known and which are new.

Any one who has experience of such labour, pleasant though it be, will recognize that a very heavy share of work has fallen to me, in which, without much kind help at home, and especially from an early and able pupil of your own, even so much as has been done could not have been accomplished.

My object now is to make a beginning of publishing, so as to clear my way of any thing I can get off my hands, to be ready for the final publication of the 'Challenger' Reports when that time comes, and to secure help now in correcting my mistakes. Need I say that these are inevitable? To escape them, I should require a universal knowledge of the world's conchology, and a universal library of conchological literature. Very little help in either direction is available here in Edinburgh.

I am very painfully aware that specialists, both in geographical and in scientific groups, will recognize oversights—failures of memory and positive blunders that may seem to them incredible. I very humbly make to them my apology beforehand, and entreat of their good will such help as lies under their hand to give in allowing me to examine specimens of the rarer species, and in sending me copies of papers I may be apt to overlook. Kind help in this direction I have already thankfully to acknowledge.

The order of publication to be followed now must depend partly on my own convenience, and partly on other exigencies.

In conclusion, I may just say that the Land-shells I have as yet scarcely touched, that the Brachiopods have been ably completed by Mr. Davidson, and of the Cephalopods, Pteropods, and Nudibranchs I have been relieved.

II. The SOLENOCONCHIA, comprising the Genera *Dentalium*, *Siphodentalium*, and *Cadulus*. By the Rev. R. BOOG WATSON, B.A., F.L.S., &c.

[Read November 21, 1878.]

THE subjoined list is an enumeration of the species of *Dentalium* referred to in detail.

DENTALIUM.

1. *D. capillosum*, Jeffr.
2. *D. ægeum*, W.
3. *D. amphialum*, W.
4. *D. ceras*, W.
5. *D. diarrhox*, W.
6. *D. entalis*, W.
7. *D. leptosceles*, W.
8. *D. circumcinctum*, W.
9. *D. acutissimum*, W.
10. *D. longitrorsum*, Reeve.
11. *D. compressum*, W.
12. *D. subterfissum*, Jeffr.
13. *D. didymum*, W.
14. *D. yokohamense*, W.
15. *D. dentalis*, Linn.
16. *D. javanum*, Sow.
17. *D. ensiculus*, Jeffr.
18. *D. tornatum*, W.

1. DENTALIUM CAPILLOSUM, *Jeffr.*; *Jeffreys*, '*Valorous*' *Report*, *Proc. Roy. Soc.* xxv. No. 173, 1876, p. 191. No. in list 26. *Do. Ann. & Mag. Nat. Hist.* 1877, xix. p. 153.

St. II. Jan. 13, 1873. Lat. 38° 10′ N., long. 9° 14′ W. Setubal. 470 fms. *Globigerina*-ooze. 1 specimen.

(?) St. 24. Mar. 25, 1873. Off Culebra Is., St. Thomas, D. W. I. 390 fms. Mud.

St. 73. June 30, 1873. Lat. 38° 30′ N., long. 31° 14′ W. 1000 fms. *Globigerina*-ooze. W. of Azores. 2 specimens.

St. 78. July 10, 1873. Lat. 37° 24′ N., long. 25° 13′ W. 1000 fms. *Globigerina*-ooze. Off San Miguel, Azores. 1 specimen, young, and 2 fragments.

Mr. Gwyn Jeffreys gives this species as taken by the 'Valorous' at St. 12, 1450 fms.; St. 13, 690 fms.; St. 16, 1785 fms.; by the 'Porcupine,' 1869, Bay of Biscay, 862 fms., N. of Hebrides, 542 fms.; and he states that Pourtales got it in the Bay of Mexico, off Bahia Honda, in 418 fms. He has described the ribs as "sharp (not rounded)." They rather seem to be sharply cut; but they are rounded on the top. L. 2·1 in. B. at mouth 0·22, at apex 0·036.

The young specimen from St. 78 has at the apex on the convex

curve a slit 0·1 in. long, but interrupted by two bridges of the shell which have not been removed when the fissure was made.

From St. 73 and St. 78 the specimens belong to the typical form; that from St. II., a remarkably large and fine specimen, belongs to a variety, *D. capillosum*, var. *paucicostatum*, W., with only about 40 instead of 65 longitudinal riblets or threads, which are very flat on their top, and are divided by furrows remarkably broad and square in form. These differences strike one very strongly at first; but the transverse sculpture is identical, and there are spots on the typical specimens which present an exactly similar form of ribbing.

From St. 24 the specimen is only a fragment, and that of a young shell of very difficult determination. Count Pourtales, however, having already found this specimen in the Gulf of Mexico, his authority relieves me from the responsibility of giving the West Atlantic as a locality for the species; so I content myself with adding a mark of interrogation to the 'Challenger' specimen.

2. Dentalium ægeum, *W.* (αἴγεος.)

St. 149 (8). Jan. 29, 1874. Off London River, Kerguelen Islands. 110 fms. Mud. 1 specimen.

Shell.—Long, conical, finely tapering, much and very equally bent, though less, of course, as the shell grows larger, thin, pure white, porcellanous, a little chalky towards the mouth, but higher up brilliant. *Sculpture.* Longitudinal ridges 30 to 35, unequal, rounded, above close, rather high, narrow, and parted by furrows which equal the ribs, but lower down these ribs become broader and flatter and the furrows widen, till towards the mouth the surface becomes uniform, and the ridges are only indicated by the faint striæ of the furrows. Under a lens the whole surface shows a faint longitudinally striated texture. On the upper part of the shell the striæ of growth are very faint; but they become rather strongly marked towards the mouth. Towards the apex the outer layers for half an inch are stripped off, and leave exposed the brilliant smooth core, presenting many longitudinal facets corresponding with the ridges of the outer layer. There is an irregular short fissure with broken edges at the apex on the convex curve. L. 2·5 in. B. at mouth 0·3, at apex 0·033.

Than *D. capillosum*, Jeffr., this is more conical, more curved, the

ridges are fewer, and the furrows between much wider and more open.

3. Dentalium amphialum, *W.* (ἀμφίαλος.)

St. 323. Feb. 28, 1876. Lat. 35° 39′ S., long. 50° 47′ W. Off the mouth of La Plata. 1900 fms. Grey mud. 2 specimens.

Animal.—Small for the shell, of a pale ruddy colour, which is deeper and browner on the foot and liver, the latter very large: two large masses of long, fine, equal captacula fill the mantle-cavity; they spring from the front of the pedestal out of which the buccal mass and the foot rise; and of these, two large bunches project through the mantle-orifice: buccal tentacles very small.

Shell.—Long, conical, nearly straight, what curve there is very equal throughout, of a dirty brownish yellow, chalky on the surface, porcellanous beneath. Both specimens are very much eroded, especially on the convex curve, and show a prodigious number of layers of shell, which is, however, thin and slight. There is a short, irregular anal fissure on the convex curve. *Sculpture.* There are about 50 very slightly raised, rounded, longitudinal ridges, the furrows between which are very much like the ridges reversed, being very shallow and open. These vary a good deal at different parts of the shell, and tend to disappear towards the mouth; they are crossed by fine, close-set, sharp, but very superficial, irregular scratches, which run elliptically round the shell, advancing on the concave and retreating on the convex curve. As the shell grows, these lines of growth become harsh and broken. L. 2, nearly. B. 0·3, nearly; least B. 0·05.

This species is somewhat like the *D. zelandicum*, Sow. "jun., N. Zealand," B.M., but in form is much stumpier, the ridges are closer, and the shell thinner. Than *D. grande*, Desh., "Japan," B.M., it likewise is stumpier in form, the ridges are less strong, the furrows less marked, the circular striæ less sharp: in *D. amphialum* the longitudinal ridges die out, while in *D. grande* they continue equally strong.

4. Dentalium ceras, *W.* (κέρας.)

St. 246. July 2, 1875. Lat. 36° 10′ N., long. 178° 0′ E. Mid Pacific, E. of Japan. 2050 fms. Grey ooze. 3 specimens.

St. 299. Dec. 14, 1876. Lat. 33° 31′ S., long. 74° 43′ W. W. of Valparaiso. 2160 fms. Grey mud. 1 specimen.

Animal.—Mantle is white, very thin, and transparent; the adductor muscles are short and weak. The liver is small, of a light greyish brown. The mouth of the mantle is very strong, of a yellowish colour, and the animal is rather fawn-coloured.

Shell.—Like one of the old drinking-horns, short, stumpy, and a good deal bent, rather thin; the newer growth porcellanous, the older chalky, and given to break off in flakes, leaving a perfectly smooth brilliant porcellanous core. *Sculpture*. The surface is covered with close-set annular striæ, which, especially on the longitudinal ribs, show like minute, crisp, round threads. The longitudinal ribs are very much stronger, but still are fine, rounded, parted by rounded furrows much like the ribs; both, but especially the furrows, are irregular in size, fresh riblets arising in the hollows. There are from 30 to 35 toward the apex, and from 70 to 80 toward the mouth. *Colour* pure white. *Edge* thin and broken at the mouth; at the apex there is an irregular ragged fissure in the convex curve. L. 1·8 in. B. at mouth 0·3, at apex 0·07.

One specimen from St. 246 is much less curved than the others. That from St. 299 (distant 4500 m. N. and S., and 6000 m. E. and W.) is much broader (L. 1·7, B. 0·36) and much more bent, but is obviously identical.

This, compared with *D. amphialum*, W., is more curved; the longitudinal striæ are much narrower, more distinct, and more persistent. Than *D. grande*, Desh., this is a much smaller and especially shorter and stumpier form, without the regular circular liræ, and the longitudinal ribs are much weaker and are closer set. Compared with *D. capillosum*, Jeffr., which it superficially resembles, it differs in texture, form, and sculpture.

5. Dentalium diarrhox, *W.* (*διαῤῥώξ*.)

St. 169. July 10, 1874. Lat. 37° 34′ S., long. 179° 22′ E. N.E. from New Zealand. 700 fms. Grey ooze. 4 specimens.

Animal.—Mantle white, body pale yellow. Captacula many, fine, long and equal, with small ovoid points. Foot and collar those of a true *Dentalium*.

Shell.—White (chalky), but porcellanous beneath the surface; rather straight, with a considerable bend near the apex, of rather rapid expansion from a very fine apex. *Sculpture*. The whole surface is faintly marked with scarcely impressed longitudinal lines of very equal interval (about 0·0055 apart); transversely

it is very faintly scratched all over by very slight lines which run elliptically round the shell. The apex has a very narrow, slightly ragged fissure, about 0·027 in. long, which lies unsymmetrically on the convex curve. L. ? B. 0·9.

This differs from *D. leptosceles*, W., in being more curved and more conical. It resembles in form the young of *D. lubricatum*, G. B. Sow., B. M., "from Australia;" but in that the transverse striæ are much less oblique, and the surface is lubricate and polished.

6. DENTALIUM ENTALIS, *Linn.*, var. D. STRIOLATUM, *Stimpson*; *Linn. Syst. Nat.* p. 1263; *Stimpson, Shells of New England*, 1851.

St. 49. May 20, 1873. Lat. 43° 3′ N., long. 63° 39′ W. Off Halifax, N. A. 83 fms. Gravel, stones.

One specimen, which, like *D. abyssorum*, Sars, is a little less attenuated than the *D. striolatum*, Stimp. Compared with the following this is rather short, bent, and *faintly* striate.

(2) Var. AGILE, *Sars, Rem. Forms &c. Norw. &c.* 1872, p. 31, pl. iii. figs. 4–15, = D. incertum, *Phil.* (*nec Desh.*), = D. fusticulus, *Brug.*

St. VIII. Feb. 12, 1873. Gomera, Canaries. 620 fms. Sandy mud and shells. 4 specimens.

In the animal of these specimens the tentacles are many, short, small, and equal. The two lobes of the liver are equal; the anal spatula is rather longer than usual. This variety is long; straight, and smooth. The Marquis de Monterosato (Nuov. Revista, 1875, p. 20) gives it as living in the Mediterranean, and as found fossil in the post-Pliocene beds of Italy (Cat. Conch. Fos. 1877, p. 8) (see also Phil. Enum. ii. 207). Sars, too, gives it as living in the North Atlantic and found in the Norwegian post-Pliocene beds.

(3) Var. ORTHRUM, W.

St. II. Jan. 13, 1873. Lat. 38° 10′ N., long. 9° 14′ W. Setubal. 470 fms. *Globigerina*-ooze. 2 specimens.

St. 75. July 2, 1873. Lat. 38° 37′ N., long. 28° 30′ W. Fayal, Azores. 450 fms. Sand. 1 specimen.

St. 145. Dec. 27, 1873. Lat. 46° 40′ S., long. 37° 50′ E. Prince Edward's Island. 150 fms. 1 specimen.

This variety is rather long, straight, and sharply striate toward the apex.

The localities for this variety are very remarkable; but I believe the specimens are really one species, and cannot be separated from *D. entalis*, L.

The geographical distribution is doubly interesting in connexion with its extreme antiquity, which Mr. Gwyn Jeffreys (B. C. iii. 192), on the authority of Hörnes (Foss. Moll. Tert. Beck. Wien, 1856), carries back even to the Miocene.

7. DENTALIUM LEPTOSCELES, *W.* (λεπτοσκελής.)

St. 160. Mar. 13, 1874. Lat. 42° 42′ S., long. 134° 10′ E. S. of Australia. 2600 fms. Red clay. 3 specimens.

Animal.—Yellow, with a large dark patch in the region of the liver. A close little bunch of captacula round the mantle-opening.

Shell.—Very attenuated, thin, brilliant, porcellanous, with longitudinal flecks of opaque white on the translucency of the shell, chiefly toward the apex where the shell thickens, very little bent, very slightly compressed between the convex and concave curves. *Sculpture.* There is some kind of flexuous longitudinal texture in the structure of the shell affecting the reflection from the brilliant surface, which is also closely and regularly scratched transversely by very minute, sharp, but superficial lines, which run round the shell a little elliptically. L. 1·5. B. 0·12, at apex 0·04.

This species in form very much resembles *D. erectum*, G. B. Sow., B. M., "from Sydney," for while some specimens of that species are more curved than this, others are even less so; but in this species the transverse striæ are very much more oblique; and in the former there is no trace of the irregular intratextural longitudinal striæ which exist here. Than *D. agile*, Sars, this is a straighter and much more cylindrical, attenuated, brilliant, and delicate shell.

8. DENTALIUM CIRCUMCINCTUM, *W.*

St. II. Jan. 13, 1873. Lat. 38° 10′ N., long. 9° 14′ W. Setubal. 470 fms. *Globigerina*-ooze. 2 young specimens.

St. 23. Mar. 15, 1873. Sombrero Island, St. Thomas, D. W. I. 450 fms. *Globigerina*-ooze. 2 fragments.

St. 122. Sept. 10, 1873. Lat. 9° 5′ to 10′ S., long. 34° 49′ to 53′ W. Pernambuco. 350 fms. Mud. 2 fine specimens.

Shell.—Very long and narrow, very slightly bent, and that almost entirely above; a very little flattened on the concave curve so as to be slightly trigonal; white, opaquely porcellanous, a little glossy, not thick but strong. *Sculpture.* Closely and regularly girt round elliptically with scratch-like puckerings in the lines of growth, of which there are about 55 in the $\frac{1}{10}$ of an inch. Longitudinally striped with fine ribs, of which there are from 17 to 20, sharp and well defined by still broader furrows toward the apex, but down the shell these increase in number and steadily decrease in definiteness till they only show as a feeble system of lines on the rounded surface. At the apex there is on the convex curve a ragged irregular fissure about 0·1 in. long. L. 1·93. B. at mouth 0·13, at apex 0·02.

As compared with *D. semipolitum*, Sow., this is a longer, straighter, more attenuated shell, with striæ stronger, blunter, and more persistent. It is not unlike *D. antillarum*, D'Orb., in texture and in size, but is much straighter and narrower, and the early ribs are much finer and fewer. It is intermediate in form between *D. erectum*, G. B. Sow., and *D. splendidum*, Desh., a little stumpier and more curved than the first and less so than the second; it is much more longitudinally ribbed and less polished than either. Than *D. Lessoni*, Desh., it is much more attenuated and never so strongly ribbed longitudinally. Than *D. inversum*, Desh., it is more strongly and persistently striate longitudinally.

The young shell is perplexingly like that of *D. entalis*, var. *orthrum*, W., but is a little straighter, broadens more slowly, and the ribs project more sharply. In maturer specimens this species is obviously much more attenuated than the former.

9. Dentalium acutissimum, *W.*

St. 218. Mar. 1, 1875. Lat. 2° 33′ S., long. 144° 4′ E. N. of Papua. 1070 fms. *Globigerina*-ooze. 2 specimens.

St. 246. July 2, 1875. Lat. 36° 10′ N., long 178° 0′ E. Mid Pacific, E. of Japan. 2050 fms. Grey ooze. 1 specimen.

Shell.—Long and very attenuated, rather straight, the curve very regular, very thin, brilliant, and glassy. *Sculpture.* The surface is crossed by very fine sharpish irregular striæ, which run very elliptically round. In the young shell the surface is very regularly and finely scratched by a great number of close-

set, regular, sharp, and very minute lines, which very gradually become more and more faint, but are still traceable even in the full-grown shell. The *colour* is pure white, transparent, and almost hyaline in the fresh shell, but in the dead shell the interior (not, as usual, the exterior) layers of the shell become opaque and chalky. The *edge* is very thin and irregularly broken. At the *apex* the end is abruptly broken off in one specimen, in the other there is an irregular fissure with an internal lining process. In the specimen from St. 246, which is full-grown but very short, a large, thin, irregularly shaped process projects, which, being obliquely cut off somewhat across the shell, supplies the anal orifice. L. 1·52, of young specimens from St. 218; B. at mouth 0·12, at apex 0·026. L. 1·14, of old and broken specimen, St. 246; B. at mouth 0·23, at apex 0·14.

Compared with *D. leptosceles*, W., this is more curved, more conical, and thus not nearly so attenuated. Compared with *D. agile*, Sars, also, this is more curved, rather more conical, and very much more delicate. It is likewise, when full-grown, apparently larger than either. Than *D. lubricatum*, G. B. Sow., this broadens more rapidly, is more brilliant, the circular striæ are stronger, the longitudinal are finer, closer, and sharper. It is also straighter than that species. Than *D. pretiosum*, Nuttall, this broadens faster and is much more brilliant.

In reference to the form of the apex, it may be observed that the separation of the *Dentalia* by the absence (*Dentalium*) or presence (*Entalis*) of the cleft process cannot be maintained. In *D. abyssorum*, Sars, there are some with a fissured process, some with a fissure without any process, some with neither fissure nor process. There are cases in which the fissure is very regularly formed, in others it looks as if it had been gnawed, in others it resembles a break; sometimes it is on the convex curve, as is the general case, sometimes on the concave, as in *D. inversum*, Desh., and in *D. subterfissum*, Jeffr.; sometimes it is irregularly lateral, as occasionally in *D. agile*, Sars.

10. Dentalium longitrorsum, *Reeve*; *Reeve, Conch. Syst.*; *C. I.* pl. ii. 9.

St. 189. Sept. 11, 1874. Lat. 9° 36′ S., long. 137° 50′ E. W. of C. York, S.W. of Papua. 28 fms. Mud. 1 specimen.

In the B.M. this is given as from "Zanzibar and China." In Reeve's C. I. this species is given as $=$*D. politum*, Desh. (*nec* L.), and $=$*D. Lamarckii*, Chemn.

11. Dentalium compressum, *W.*

St. 24. Mar. 25, 1873. N. of Culebra Island, St. Thomas, Danish West Indies. 390 fms. Mud. 1 specimen.

Shell.—Compressed between its concave and convex curves to the extent of 0·016 in.; bent, as in young shells, a little more towards the apex, and the curve greater on the convex slope, slightly carinated on each side. *Sculpture.* Faint, but very regular, longitudinal striæ, about 0·01 in. apart, apparently in the texture of the shell, which thus seems to be built up of minute, square-faced rods laid side by side. Crossing these at right angles are sharp, irregular scratches in the line of growth, nearly circular, but bent a little forwards on the concave curve. L. 0·45. B. at mouth 0·05 (least), 0·06 (greatest), apex 0·019.

It is very possible that this may be a *Siphodentalium*, as Mr. Gwyn Jeffreys suggested; but in the absence of the animal and the rubbed condition of both ends of the shell it is impossible to say. It resembles *S. tetragonum*, Brocchi, more than any other; but the want of the angles, the different character of the longitudinal striæ, and, above all, the compression, separate it completely. There is only the one dead discoloured and somewhat rubbed specimen.

12. Dentalium subterfissum, *Jeffr.*; *J. Gwyn Jeffreys, Ann. & Mag. Nat. Hist.* 1877, xix. 154.

St. 78. July 10, 1873. Lat. 37° 24′ N., long. 25° 13′ W. Azores. 1000 fms. *Globigerina*-ooze. 10 specimens or fragments.

St. 85. July 19, 1873. Lat. 28° 42′ N., long. 18° 6′ W. Palma, Canaries. 1125 fms. Volcanic sand. 1 fragment.

St. 120. Sept. 9, 1873. Lat. 8° 37′ S., long. 34° 28′ W. Pernambuco, S. America. 675 fms. Mud. 2 fragments.

A species peculiar as having the apical slit on the concave curve. The animal is unknown.

Mr. Gwyn Jeffreys got it in the 'Porcupine,' 1869, off the W. coast of Ireland, in 1180–1476 fathoms, and in the 'Valorous' at St. 12, in 1450 fathoms.

13. Dentalium didymum, *W.* (*δίδυμος*, as *two*-sided. Also from St. Thomas, also as doubtful.)

St. 24. St. Thomas, N. of Culebra Island, Danish W. Indies. 390 fms. Mud.

Shell.—Extremely attenuated, very slightly curved, a little flattened laterally, and that chiefly toward the convex curve, so that the form is slightly trigonal, porcellanous, pure white, brilliant. *Sculpture.* Very fine, irregular scratches run round the shell, the surface of which is not perfectly uniform; there are very faint indications of longitudinal texture, and there is in the substance of the shell a certain transverse flocculence. Towards the mouth the shell is extremely thin as usual; but towards the apex it becomes thick from the smallness of the bore, which lies not in the centre but nearer the convex curve of the shell. L. 1·08. B. 0·06, at apex 0·04.

This measure is taken from the largest of six fragments, none of which preserve the apex of the shell.

14. Dentalium yokohamense, *W.*

St. 233. May 17–26, 1875. Yokohama, Japan. 8–14 fms. Mud.

Shell.—Much curved when young, becoming nearly straight with later growth, little conical, rather strong, opaque, yellowish white, quite dull, but not chalky. *Sculpture.* Irregular, slightly elliptical, lines of growth, a little puckered, generally slight, but sometimes sharp and even; towards the mouth faintly imbricated; occasionally marked by a deep furrow-like constriction of the shell. The *longitudinal ribs* are 8 to 9 in number, equal, rounded, rather strong, but not very prominent. These are parted by furrows, round and open, very shallow, and of very unequal breadth. In these furrows, one, two, or even three thread-like riblets appear, and in the whole texture the lens shows a tendency to a longitudinal rod-like structure. At the apex the shell is squarely truncate, and in the young shell there is, on the convex slope, a slight ragged fissure. L. 1·2. B. at mouth 0·15, at apex 0·003.

The ribs here are much less sharp than they are in *D. dentalis*, L., and there is no trace of the exquisite longitudinal fretted striæ which cover the furrows in that species. The sharp intercostal striæ of *D. octogonum* are quite absent here, and in that species, which is much more bent, the ribs are much wider apart and more equally parted.

15. Dentalium dentalis, *Linn.*; *Linn. Syst. Nat.* 1263; *Born, Mus.* 432, xviii. 13. Living in the Mediterranean, the S.W. of France, and the Canaries.

St. 75 (?). July 2, 1873. Fayal, Azores. 50 to 90 fms.

Dec. 1873. Simon's Bay, Cape of Good Hope. Sand and shells, 15 to 20 fms. Two fragments, one of them, however, consists of the apex and apical process.

Mr. Gwyn Jeffreys was good enough to identify these specimens for me, their state and the newness of the locality making confirmation specially desirable.

16. Dentalium javanum, *Sow.*; *Sow. Thes. Conch. Dent.* sp. 39, f. 12; *Reeve, C. I.* pl. iii. sp. 14.

Sept. 7, 1874. Torres Strait, C. York. 3–11 fms. 2 young specimens.

St. 186. Sept. 8, 1874. Lat. 10° 30′ S., long. 142° 18′ E. Wednesday Island, Cape York. 8 fms. Coral sand.

St. 188. Sept. 10, 1874. Lat. 9° 59′ S., long. 139° 42′ E. W. of C. York, Australia, off the S.W. point of Papua. 28 fms. Mud. 2 specimens.

This species is given in B.M. as from Malacca. *D. octogonum*, L. (which this much resembles), has much stronger intracostal striæ, and the ribs are much more sharply prominent.

17. Dentalium ensiculus, *Jeffr.*; *J. Gwyn Jeffreys, Val. Exp., Ann. & Mag. Nat. Hist.* 1877, xix. 154.

St. 23. Mar. 15, 1873. Off Sombrero Island, St. Thomas, D.W.I. 450 fms. *Globigerina*-ooze. 9 specimens or fragments.

Mr. Gwyn Jeffreys got this species from St. 12, 1450 fms.; St. 16, 1785 fms.; West of Ireland, 1366 fms.; Bay of Biscay, 862 fms.; Portugal, 740–1095 fms.

The bore of the shell lies quite on the convex side, and toward the apex is small.

18. Dentalium tornatum, *W.* (Turned as in a lathe.)

St. 173–4. July 29, 1874. Levuka, Fiji. 12 fms. 6 specimens.

Shell.—Small, narrow, very finely tapering, slightly but very equably bent, strong, of a quill-like translucency and brilliance. *Sculpture.* The upper part of the shell is encircled by deep,

close-set, slightly oblique grooves, which look as if they were turned in a lathe. Further down the shell they become shallower, and cease at last rather abruptly. The flat bands of the shell-surface which part them are of variable width, and increase with the growth of the shell from about 0·011 to twice that amount. The front part of the shell is closely, minutely, obliquely striated in the line of growth, with here and there a very faint depression, just suggestive of the grooves above. There is besides these a faint transverse flocculence in the substance of the shell. *Mouth-edge* thin, not contracted, very slightly oblique. The *apex* is abruptly broken across, and there the edge of the shell is thick, and from the opening there projects a minute round pipe about 0·008 broad, and 0·012 long, slightly striated obliquely, abruptly broken off at the end. In most of the specimens only the mere stump of this delicate tube remains. L. 0·55. B. 0·038, apex 0·018.

This species seems to vary a little in breadth.

Siphodentalium.

1. *S. platamodes*, W.
2. *S. tytthum*, W.
3. *S. pusillum*, W.
4. *S. tetraschistum*, W.
5. *S. dichelum*, W.
6. *S. prionotum*, W.
7. *S. eboracense*, W.

1. Siphodentalium platamodes, *W.* (πλαταμώδης, as flat on the sides.)

St. 24. St. Thomas, N. of Culebra Island, Danish West Indies. 390 fms. Mud. 4 specimens.

Shell.—Small, solid, finely tapered, curved, especially toward the apex, five-sided, with four sharp corners, which are nearly right angles, and one very obtuse angle along the concave curve; these all tend to disappear toward the apex, the young shell being rounded. *Sculpture.* The angles of the shell project more or less in a sharp rounded rib, which is sometimes double; there are a few longitudinal striæ, regular, 0·01 in. apart, strongest near the angles, more or less obsolete as they recede from these. Neither end is fresh enough for description. L. 0·47. B. 0·049.

I have hesitated a good deal in separating this from *S. tetragonum*, Broc.,=*quinquangulare*, E. For., with which it agrees more

closely than with the *S. pentagonum*, Sars. Here, however, the longitudinal ribs are much closer, as well as much more obsolete; the shell is more curved throughout its whole length, is more attenuated, and retains its square form and sharp angles instead of becoming rounded as in *S. tetragonum*, Brocchi. Amidst all the variations of that very variable form I have not seen any that connects it with this species.

2. Siphodentalium tytthum, *W.* (*τυτθός*.)

St. 24. March 25, 1873. Culebra Island, St. Thomas, D. W. I. 390 fms. Mud. 4 specimens.

Shell.—Minute, very conical, *i. e.* broadening rapidly, much bent, very thin, but not hyaline, apparently horny when living, and becoming opaque when dead, and then also glossy but not brilliant. *Sculpture.* Some very faint traces of circular striæ on the lines of growth. *Mouth-edge* very thin and chipped. *Apex* broken, but in one specimen showing the two lateral clefts common in the genus. L. 0·22. B. at mouth 0·049, at apex 0·013.

In texture and in general form this is like *S. vitreum*, Sars, but it broadens much faster and is more curved.

3. Siphodentalium pusillum, *W.* (*pusillus*.)

St. 85. July 19, 1873. Lat. 28° 42′ N., long. 18° 6′ W. Palma, Canaries. 1125 fms. Volcanic sand. 2 specimens.

Shell.—Minute, attenuated, slightly bent, thin, transparent, irregularly banded with opaque white, which runs elliptically round the shell. *Sculpture.* There is no trace of longitudinal striæ, but the whole surface is sharply scratched with minute transverse striæ, which run (as usual) not directly round the shell, but advance on the concave and retreat on the convex curve. L. 0·12. B. at small end 0·01, at broad end 0·02.

These specimens are both young, and both ends are chipped. It is straighter and more tumid than *Siphodentalium minutum*, H. Ad. (Gulf of Suez, *MacAndrew*), and not contracted at the mouth. It is also straighter and more tumid than *D. filum*, Sow. (in part), = *gracile*, Jeffr., Journ. de Conch. 1872, p. 140, v. 5, but more curved and broader than the young of *D. capillosum*, Jeffr. It is much larger, more tumid, and straighter for the same length than *Siphodentalium lofotense*, Sars.

4. Siphodentalium tetraschistum, *W.*

St. 113 a. Sept. 2, 1873. Anchorage off Fernando Noronha. 7–25 fms. 1 specimen.

Shell.—Cylindrical, tapering, bent and attenuated from about the middle to the apex; toward the mouth very slightly contracted. It is rather strong, and has the dull gloss and white translucency of a quill. There are two opaque bands round the apex. *Sculpture.* There are traces, exceedingly faint, of fine close-set striæ, which run elliptically round the shell on the lines of growth, and in some lights there is just a reflection as of some sort of remote longitudinal texture (very like that in *S.* (*Dischides*) *bifissum*, Wood). The *edge* of the mouth slopes backwards very obliquely from the concave to the convex side of the shell; it is thick, and all round it is smoothly rounded off. The *apex* projects on the convex side of the shell, and is split by four opposite, shallow, unequal, irregular, rough-edged, gaping clefts, so arranged as to leave the teeth at the convex and concave curves and at the two sides. The bands round the apex are two narrow callus-like ribs. L. 0·298. B. at mouth 0·03, at broadest 0·035, at apex 0·017.

This species approaches nearest to *Siphodentalium* (*Dischides*) *bifissum*, Wood, but that species has only two, and these lateral, narrow, deep, and regular, posterior clefts; its mouth is squarely cut off with a thin and jagged edge; its shell is very little contracted at the mouth, and contracts slowly but constantly all the way to the apex; is also longer, more bent, and thinner. *S. lofotense*, Sars, and *S. vitreum*, Sars, which have the four posterior clefts, are totally unlike in texture and in form.

5. Siphodentalium dichelum, *W.* (*δίχηλος.*)

July 29, 1874. Levuka, Fiji. 12 fms. 1 specimen and 2 fragments.

Shell.—Long, slightly swollen at about three fifths of its length; the swelling bulges on the concave curve, but the convex curve is uninterrupted; between these two curves it is compressed by one sixth of its breadth, a little contracted in front, bent and attenuated toward the apex; thin, brilliant white, almost hyaline, with a few minute, transverse, curdy streaks, but weathering to opaque. There is an opaque band round the apex.

Sculpture. Most faint and delicate microscopic scratches on the lines of growth, with a minute transverse flocculence and some vague indication of longitudinal texture in the substance of the shell. The *mouth* is large, very oblique, with a smoothly rounded edge, which is sharp on the inner margin; both it and the posterior opening are oval. The *apex*, which is small, is split on either side by a deep, narrow, slightly widening, smooth, clean-cut, but not perfectly regular cleft, which is evidently carried up the shell as the growth of the animal demands, for it cuts across the transverse striæ, as Mr. Searles Wood remarks is the case with *S.* (*Dischides*) *bifissum.* Within the opening a short, minute, longitudinal, rib-like process projects along the middle of the posterior (*i. e.* convex curve) wall; a little further in a thin, narrow, circular callus runs round the opening. L. 0·35. B. at mouth 0·032, broadest 0·055, apex 0·022.

This is much larger than *S. tetraschistum*, W., and much less cylindrical, being much more contracted towards the mouth. The posterior internal rib is a curious feature. It shows *through* the shell like a crack or depression, but is a true internal rib.

6. Siphodentalium prionotum, *W.* (*πριονωτὸς, jagged.*)

St. 185. Aug. 31, 1874. Lat. 11° 35′ S., long. 143° 3′ E. Raine Island, C. York. 155 fms. Sand. 2 specimens and 2 fragments.

Shell.—Long, narrow, tapering, gently contracted at the mouth, slightly bent throughout; rather strong, polished, but hardly brilliant, translucent white. *Sculpture.* Very faintly transversely striated on the surface, and a very minute flocculence in the same direction in the texture. For the breadth of the shell the *mouth* is large, perfectly round, oblique, with a smoothly rounded edge, which is sharp on its inner margin. The *apex* is small, much chipped, but that in such a way as in all the specimens to produce a shallow rounded hollow on either side, with a sharp projecting point before and behind. Within the opening a short excessively minute riblet runs out along the middle of the posterior wall; it shines through the shell like a depression, being a little more transparent than the shell-wall. L. 0·328. B. at mouth 0·028, greatest 0·039, at apex 0·013.

This species differs from the previous in being much narrower

and having no swelling. From *S. tetraschistum*, W., it differs in being more elongated, more attenuated behind, and in the character of the posterior opening.

7. Siphodentalium eboracense, *W.*

Sept. 7, 1874. Torres Strait, Cape York. 3–11 fms. 3 specimens.

Shell.—Small, narrow, tapering very gradually throughout; toward the apex bent, thin, brilliant, translucent and transparent in alternate bands. *Sculpture.* There are a few remote, irregular, oblique, transverse striæ; in the young shell the whole surface is covered with longitudinal striæ, excessively minute (0·0005 in. apart), sharp and regular, but which seem very easily rubbed off*, and which disappear towards the mouth. The *mouth* is round, very oblique, sharp, and thin. The *apex* is minute, and is broken straight across and somewhat chipped. L. 0·185. B. 0·024, at apex 0·008.

Than *S. prionotum*, W., this is smaller, straighter, but toward the apex more bent, not narrowed at the mouth; smaller at the apex, and the whole texture of the shell is different.

Than *S. vitreum*, S., this is less cylindrical, is not contracted toward the mouth, and is much smaller toward the apex.

Cadulus.

1. *C. colubridens*, W.
2. *C. vulpidens*, W.
3. *C. rastridens*, W.
4. *C. sauridens*, W.
5. *C. gracilis*, Jeffr.
6. *C. simillimus*, W.
7. *C. curtus*, W.
7a. *C. curtus*, var. *congruens*, W.
8. *C. obesus*, W.
9. *C. tumidosus*, Jeffr.
10. *C. exiguus*, W.
11. *C. ampullaceus*, W.

1. Cadulus colubridens, *W.*

St. 169. July 10, 1874. Lat. 37° 34′ S., long. 179° 22′ E. N.E. point of New Zealand. 700 fms. Grey ooze. 1 specimen.

Shell.—Like an adder's fang; long, sharp, bent, very slightly flattened, swollen near the broader end. The swell, which is faintly angulated and is at one fourth of the length, is chiefly

* On two specimens it is barely traceable.

on the convex curve, but is visible on the concave curve too. From the angulation, the curve is very equable in either direction. About two thirds along toward the apex it bends more back. The shell is thin, brilliant, semiopaque, white. *Sculpture.* Very faint and fine scratches on the lines of growth. *Mouth* large, oval, very slightly flattened on the front side, from which the thin sharp edge is obliquely cut off towards the convex curve. The *posterior opening* is much smaller, nearly round, and the edge is thin and chipped. L. 0·58. B. at mouth 0·067, at swell 0·1, at apex 0·033.

This is twice the size of *C. gadus*, Montague; but it resembles that in the angulation, which, however, is here more marked at the summit of the swelling; its expansion from the smaller end is much more gradual, and its contraction from the angulation on to the mouth is more rapid.

2. Cadulus vulpidens, *W.*

St. 24. Mar. 25, 1873. Culebra Island, St. Thomas, D. W. Indies. 390 fms. Mud. 1 specimen.

Shell.—Like the canine tooth of a small Carnivore; long, sharp, bent, swollen (a little obliquely) nearer the broader end. The swelling is greatest on the convex curve, and lies there a little nearer the mouth (about one fourth of the length) than it does on the concave, where it is at about one third of the length. This obliquity makes the form a little unsymmetrical. From the swelling the shell contracts more rapidly towards the mouth. Toward the apex the bend increases, and the end of the shell is a very little contracted. The shell is pretty strong, brilliant, opaquish white. *Sculpture.* Very minute, but sharp, microscopic scratches on the lines of growth. *Mouth* small, round, obliquely truncated backward toward the convex curve. *Edge* thin and sharp. *Posterior opening* round; the edge thick, flat, slightly gnawed and broken, projecting a little on the convex curve side. L. 0·35. B. at mouth 0·039, at swelling 0·069, at apex 0·03.

This is smaller and less symmetrical than *C. colubridens*, and the mouth is much smaller. Than *Dentalium clavatum*, Gould, which it much resembles, this is more contracted in front and less so behind, and has more of angulation in its tumidity. Than *D. gadus*, Mont., this is a much less stumpy shell, being less swollen

in the middle, and more drawn out before and behind; it is also straighter. *Cadulus ventricosus*, Bronn, has the swelling nearer the mouth.

3. Cadulus rastridens, *W.*

St. 24. Mar. 25, 1873. Culebra Island, St. Thomas, Danish W. Indies. 390 fms. Mud. Many specimens.

Shell.—Like the tooth of a rake, small, narrow, bent, swollen, and on the convex curve very faintly angulated at about five eighths of its length, from which point both the bend and the narrowing of the shell is greater (proportionally) toward the mouth than it is toward the apex. Between the back and the belly there is a very slight compression of the shell. It is pretty strong, brilliant, more or less obscurely banded transversely, with alternate equal threads of opaque and transparent white. *Sculpture.* Very faint, superficial, transverse scratches. *Mouth* pretty large, not at all oblique, thin, sharp, and chipped; *posterior opening* round, straight; edge thickened, and less chipped than the mouth. L. 0·119. B. at mouth 0·015, at swelling 0·023, at apex 0·01.

4. Cadulus sauridens, *W.*

St. 24. March 25, 1873. Culebra Island, St. Thomas, D. W. I. 390 fms. Mud. 1 specimen.

Shell.—Long, narrow, scarcely bent, swollen very slightly near the middle of the convex curve, just perceptibly and a little more anteriorly on the concave; both the bend and the contraction are greater towards the apex than towards the mouth. There is a very slight compression between the back and the belly of the shell. It is thin, brilliant, scarcely opaque, white. *Sculpture.* There is none, except perhaps some very faint microscopic traces of longitudinal texture. *Mouth* rather small, very oblique; edge thin, but not chipped. *Apical opening* small, straight across the shell, thin, chipped. L. 0·12. B. at mouth 0·01, at swelling 0·02, at apex 0·009.

This differs from *C. rastridens*, W., in being less bent, less swollen, the swelling more central, more apparent on the ventral curve; the shell is less attenuated posteriorly, and more so antetiorly; there is no transverse sculpture; the mouth here is oblique, the shell at the anal opening is not thickened, and both ends are narrower. Than *C. gracilis*, Jeffr., this is much smaller,

more attenuated, has a gibbous swelling, and not a mere equable enlargement, and has both openings much smaller.

From *C. Jeffreysi*, Monter., it differs still more strongly in these very respects, except that this is nearer it in size.

5. Cadulus gracilis, *Jeffr.*; *J. Gwyn Jeffreys, Ann. & Mag. Nat. Hist.* 1877, xix. p. 157.

St. 75. July 2, 1873. Lat. 38° 37′ N., long. 28° 30′ W. 450 fms. Sand. 1 specimen, young.

St. 78. July 10, 1873. Lat. 37° 24′ N., long. 25° 13′ W. Off San Miguel, Azores. 1000 fms. *Globigerina*-ooze. 2 specimens.

St. 85. July 19, 1873. Lat. 28° 42′ N., long. 18° 6′ W. Canaries. 1125 fms. Volcanic sand. 2 specimens, young.

Mr. Jeffreys got one specimen in the 'Valorous' at St. 13, 690 fms. He was good enough to verify my determination of this species. It is very like *C. Jeffreysi*, Monter.; but is larger and a little compressed (in the proportion of $\frac{1}{15}$) between the convex and concave curves as compared to its breadth, which is not the case in *C. Jeffreysi*. It is not so swollen, and the posterior opening is larger than in that species.

6. Cadulus simillimus, *W.*

St. 185. August 31, 1874. Lat. 11° 35′ S., long. 144° 3′ E. Raine Island, Cape York. 155 fms. Sand. 2 specimens.

St. 187. September 9, 1874. Lat. 10° 36′ S., long. 141° 55′ E. W. of Cape York. 6 fms. Coral sand. 2 specimens.

Shell.—Very like *C. gracilis*; rather broad, narrowed at both ends, very slightly and symmetrically bent, but a little more towards the mouth, with a very slight bulge, which just shows on the concave curve. It is thin, polished, translucent (weathering opaque), with an opaque ring near the apex. *Sculpture.* Very minute and faint superficial oblique striæ, with a faint flocculence in the substance of the shell. *Mouth* rather large, oblique; edge thin, but rounded. *Apical opening* small, thin, and chipped. L. 0·16. B. at mouth 0·02, greatest 0·036, at apex 0·014.

This differs from *C. gracilis*, Jeffr., in being broader, with a slight bulge on the concave curve, in being a little more bent, and

in not being compressed. It is also smaller. It is extremely like *C. Jeffreysi*, Monter., but is a little more bent, especially in front, is larger, and seems a thinner shell.

7. Cadulus curtus, *W.*

St. 24. March 25, 1873. Culebra Island, St. Thomas, D. W. Indies. 390 fms. Mud. 30 specimens.

Shell.—Short, broad, narrowed at both ends, scarcely bent, and that almost wholly near the mouth; swollen in the middle, so as to bulge a little on the concave curve. Though the mouth is larger than the apex, the whole shell is a little more pinched in in front than behind, and is very slightly laterally compressed (in the proportion of about 14 to 15). It is thin, polished, translucent white, with one, sometimes two, opaque rings near the apex. *Sculpture.* Only under a high power of the microscope can some very close transverse striæ be seen in the texture of the shell. *Mouth* rather large, very slightly oblique; edge thin and generally much chipped. *Apical opening* small, straight, chipped. The opaque rings result from thickening, caused by a thin projection which narrows the opening. L. 0·1. B. at mouth 0·019, thickest 0·03, apex 0·012.

Than var. *congruens*, W., this is not only very much smaller, but here the mouth is oblique, and the shell straighter behind and more bent in front, where, too, it is more pinched in. It is nearly of the same length as *C. obesus*, W., but is very much narrower.

7*a*. Cadulus curtus, var. congruens, *W.*

St. 24. March 25, 1873. Culebra Island. St. Thomas, Danish W. Indies. 390 fms. Mud. 2 specimens.

This differs from *C. curtus*, W., in being one third larger; the mouth is perhaps less oblique, but being in both specimens much chipped, this may be accidental. The most remarkable feature of difference is that it is perfectly round, and not, like the other, laterally compressed. I attribute this difference to age. At all events, in the absence of a larger series of specimens, I believe it safer to include both under one species.

8. Cadulus obesus, *W.*

St. 24. March 25, 1873. Culebra Island, St. Thomas, D. W. Indies. 390 fms. Mud. 10 specimens.

Shell.—Short, very broad, narrowed at both ends, little bent, and that almost entirely toward the mouth, very much swollen in the middle, and bulging a good deal on the concave curve, a little more attenuated behind, and very slightly laterally compressed (in the proportion of 14 to a little less than 15). It is pretty strong, polished, translucent white, with one, sometimes two opaque rings near the apex. *Sculpture.* A few very vague and faint, distant transverse lines. *Mouth* rather large, straight; edge thin and much chipped. *Apical opening* small, straight, chipped, narrowed inside by a minute shelf-like projecting ring. L. 0·109. B. at mouth 0·02, thickest 0·04, at apex 0·01.

This is nearly of the same proportions as *C. curtus*, except being very much broader; like that, too, it is narrowed laterally. I have hesitated very much in making it more than a variety; but, on the whole, think it safer to reckon it as distinct. One specimen has its breadth exaggerated by a gibbous pad of enamel.

9. Cadulus tumidosus, *Jeffr.*

St. 78. July 10, 1873. Lat. 37° 24′ N., long. 25° 13′ W. Azores. 1000 fms. *Globigerina*-ooze.

St. 85. July 19, 1873. Lat. 28° 42′ N., long. 18° 6′ W. Canaries. 1125 fms. Volcanic sand.

J. Gwyn Jeffreys, 'Valorous' dredgings, Ann. & Mag. N. H. 1877, xix. p. 156:—From St. 12, 1450 fms. In the 'Porcupine,' Channel slope, 557 fms.; Bay of Biscay, 292–1095 fms. 'Josephine' expedition, 110–550 fms. Fossil at Messina.

Mr. Gwyn Jeffreys verified my determination of this species.

I have failed to see the callus-rib in the mouth; but there is within the posterior opening a circular rib or narrow sharp ledge, which from the outside is seen as an opaque band, but with some difficulty may be seen within as a narrow projecting shelf. The edge of the apex seems to me rather chipped than regularly notched.

10. Cadulus exiguus, *W.*

St. 24. March 25, 1873. Culebra Island, St. Thomas, D. W. I. 390 fms. Mud. 2 specimens.

Shell.—Very small, short, broad, pinched in, and projecting at both ends; very slightly bent, and that almost entirely in front; very much swollen in the middle, bulging on the concave curve,

a little more attenuated behind; pretty strong, polished, translucent and white, with an opaque white band round the apex. *Sculpture* none. *Mouth* large, straight; edge thin and chipped. *Apical opening* small, straight, chipped, narrowed inside by a minute shelf-like projecting ring. L. 0·076. B. at mouth 0·016, at broadest 0·035, at apex 0·01.

It differs from *C. ovulum*, Phil., in being very much smaller, rounder, and contracted into a tube at either end.

11. Cadulus ampullaceus, *W.*

St. 24. March 25, 1873. Culebra Island, St. Thomas, D. W. Indies. 390 fms. Mud. 1 specimen.

Shell.—Small, round, but not symmetrical in its two curves, contracted in front, pinched in behind so as to form a short tube, swollen, the fullest bulge lying behind the middle. Pretty strong, polished and translucent white, with an opaque band close to the apex. *Sculpture* none. *Mouth* large, very slightly oblique; edge thin and chipped. *Apical opening* slightly oval, small, straight, roughened, narrowed inside by a flat, concentrically puckered, and margined ring, which occupies nearly half its diameter (0·014 and 0·006). The margin (about 0·001 thick) of this ring is formed by the projecting end of a short pipe (about 0·005 long) which passes up into the interior of the shell. L. 0·08. B. at mouth 0·02, at broadest 0·047, at apex 0·016.

This species is not only much smaller than *C. ovulum*, Ph., from the Mediterranean, but is obviously very different in form and proportions. It differs from *C. exiguus*, W., in being much rounder, has no tube anteriorly, is not nearly so elongated posteriorly, and is provided with a distinct posterior pipe.

Descriptions of new Coleoptera of Geographical Interest, collected by Charles Darwin, Esq. By FREDERICK H. WATERHOUSE, Librarian to the Zoological Society of London. (Communicated by Dr. J. MURIE, F.L.S.)

[Read December 5, 1878.]

THE insects described in the present paper were collected by Mr. Charles Darwin, and have been in my father's collection for many years undetermined.

The first that I have to notice is an example of Brachelytra belonging to the genus *Phytosus*, and from the Falkland Islands. The species of this genus have hitherto only been recorded from Europe, Morocco, the Canary Islands, California, and Kerguelen Island. It should be noticed of that here described that it has unusually long and slender claws; this peculiarity is noticed by my brother in the species described by him from Kerguelen Island, but this is a small species.

The second species here referred to is also from the Falkland Islands: it belongs to the genus *Choleva*. The species of this genus are widely distributed, and have been recorded from Europe, N. Africa, Madeira, Tasmania, N. America, Venezuela, and Chili. That now denoted is a very remarkable one, on account of its elliptical form and strong punctuation.

The third insect I have to record is a species of the genus *Elmis* from St. Helena, of which Mr. Darwin found two specimens. This genus was not known to occur in this locality when the late Mr. Wollaston published his work on the Coleoptera of the island; it is therefore an interesting addition to the fauna.

The next species also comes from the same locality; it belongs to the widely-distributed genus *Anthicus*. This genus, however, has not as yet been recorded from there. Mr. Darwin also obtained the following species from St. Helena, recently described by the late Mr. Wollaston:—*Oxytelus alutaceifrons*, *Cryptophagus gracilipes*, *Notioxenus ferrugineus*, and *Homœodera pygmæa*.

I have also called attention to a very interesting species of *Scaphisoma* from Rio de Janeiro, remarkable for its elongate compressed form and from being the first species of this genus that has been recorded from South America.

It remains now for me to mention a new genus of Philhydridæ from the Cape of Good Hope, allied to *Helophorus*. The special

interest attaching to this genus is the presence of two ocelli, a peculiarity extremely rare in Coleoptera, and not hitherto known in this family. There are only two species of the whole group known from S. Africa.

The types of the following species are in the Collection of the British Museum.

PHYTOSUS DARWINII, sp. nov.

Light pitchy brown, not very dull; the head and the fourth and fifth segments of the abdomen nearly black. Head scarcely longer than broad, narrowed in front, gently rounded at the sides, extremely finely coriaceous, and very finely and moderately thickly punctured. Antennæ scarcely as long as the head and thorax together; the first two joints are elongate, the third moderately so; the fourth to the tenth nearly equal, slightly widening towards the apex, sparingly pubescent. Thorax slightly broader than the head, and a little broader than long, broadest a little in front of the middle, gradually narrowed behind, sculptured in the same manner as the head; the sides gently rounded in front, and gently sinuate behind. Elytra as broad as the thorax, but much shorter, extremely finely coriaceous; punctures slightly more distinct than on the head and thorax. Abdomen slightly widening towards the apex; extremely finely coriaceous and finely punctured, very sparingly pubescent, and slightly more glossy than the other parts of the insect. Legs sparingly pubescent, and the claws very long and slender. Length $4\frac{1}{2}$ millims.

Hab. Falkland Islands.

CHOLEVA FALKLANDICA, sp. nov.

Rather elongate elliptical, not very convex, of a dull dark brown, the head nearly black, clothed with fine brownish pubescence. Head broad, narrowed in front, obliquely narrowed behind the eyes, very coarsely punctured. Antennæ a little longer than the head and thorax, rather stout, and of a pitchy black, paler at the base. Palpi pitchy. Thorax much broader than the head, slightly narrowed in front, broadest just before the base, a little broader than long, very coarsely and thickly punctured. Elytra at the base scarcely broader than the thorax, slightly wider a little behind the middle, and then narrowed to the apex, very thickly and rather coarsely punctured, but not so coarsely as the head and thorax, without striæ. Legs very stout, pitchy; the tarsi

paler, the anterior very much dilated, the basal joint transverse. Length 3 millims.

Hab. Falkland Islands.

ELMIS BRUNNEUS, sp. nov.

Moderately convex, dull pitchy brown, paler beneath. Head nearly black. Thorax broadest behind, gradually narrowed in front, slightly broader than long, densely and finely punctured, the sides finely margined; there is a slight indication of an impression on each side at the base. Elytra about twice as long as the thorax, at the base a little wider than the base of the thorax, more ample posteriorly, abruptly and obliquely narrowed at the apex, strongly striated, the striæ strongly punctured, the intervals convex, dull. Length 2 millims.

Hab. St. Helena.

Most nearly approaches *E. cupreus*, but its shorter and broader form and opaque surface separate it from that and other allied species.

ANTHICUS WOLLASTONI, sp. nov.

Reddish yellow, very glossy, not much convex, the legs rather paler. Head across the eyes a little wider than the thorax, not quite as long as broad, obliquely (but not much) narrowed behind the eyes; not visibly punctured; the eyes moderately prominent. Antennæ a little longer than the head and thorax taken together; the four apical joints distinctly larger than the preceding joints. Thorax a trifle longer than broad, very convex, not visibly punctured, moderately narrowed posteriorly, the greatest width rather in front of the middle; the sides rounded in front; thickly beset with long yellow pubescence, with an impressed line on each side near to the margin and parallel to it, not quite extending to the front margin. Elytra at the base of the same width as the base of the thorax, one third longer than the head and thorax taken together, twice as broad in the middle as at the base, obliquely narrowed to the apex, extremely delicately and rather sparingly punctured. Length $1\frac{1}{3}$ millim.

Hab. St. Helena.

The very small size, the pubescent thorax, and the angular sides to the elytra separate this species from the others of the genus.

SCAPHISOMA ELONGATUM, sp. nov.

Very elongate-ovate, much convex, and extremely glossy black. Head gradually widening towards the base, the greatest width being just behind the eyes; not punctured. Clypeus slightly narrowed in front; the front margin pitchy red. Antennæ very long and slender, the basal joints being pitchy red, the others darker, scantily covered with very long black hairs. Eyes scarcely projecting beyond the margin of the head. Palpi pitchy red. Thorax the same width as the head in front, but rapidly widening towards the base; very convex, as long as the width at the base, and not punctured. The elytra scarcely broader than the thorax at the base, and gradually tapering towards the apex to about half the width; very convex, the extreme tips pitchy red; sparingly and excessively delicately punctured. Legs long, slender, and of a uniform pitchy red. The last two segments of the abdomen pale pitchy red, with a few stiff hairs projecting from the apex of the last segment. Length $2\frac{1}{4}$, width $1\frac{1}{4}$ millim.

Hab. Rio de Janeiro.

This species is remarkable for its elongate narrow form; therefore quite unlike any other of the genus, and not readily to be confounded with them.

PROSTHETOPS, gen. nov.

Head free. Maxillary palpi stout, the apical joint distinctly longer than the preceding joint, fusiform. Eyes large, prominent, not divided by a canthus. Clypeus about twice as broad as long, its greatest width across the middle; the margins slightly reflexed; anterior angles rounded; the front margin with a deep triangular incision in the middle. Thorax transverse, much narrowed behind. Scutellum very small, triangular. Elytra moderately elongate, much broader in the middle than at the base and apex, the apices separately rounded. Legs and tarsi as in *Helophorus*. There are two distinct ocelli on the head, situated rather behind the middle of the eyes, widely separated.

The presence of frontal ocelli in this genus is very interesting, their existence in the Coleoptera being of very rare occurrence.

PROSTHETOPS CAPENSIS, sp. nov.

Rather flat, bronzy black, rather dull except the elytra, which are moderately shining. Head rather large; forehead with a raised mark in the form of an *x* between the eyes; the eyes prominent. Clypeus with the margins gently reflexed and thickened. Thorax

scarcely as broad as the head across the eyes, broader than long, the widest part a little in front of the middle, obliquely narrowed in front, much narrowed behind, with two longitudinal ridges on the disk, which meet in the middle and at the front margin; the sides finely crenulate; strongly and closely punctured, which gives it a dull appearance as compared with the elytra. Elytra at the base broader than the thorax, and about three times as long, considerably broader near the middle, and then narrowed towards the apex, which is about as broad as the base; strongly punctate-striate, the surface rather undulating; there is a strong transverse impression on the disk near the middle. Legs rather long and slender; tibiæ pitchy. Length $2\frac{3}{4}$ millims.

Hab. Cape of Good Hope.

Geographical Distribution of Indian Freshwater Fishes.—Part III. Conclusion. By FRANCIS DAY, Esq., F.L.S. &c.

[Read December 5, 1878.]

IN the pages of the Journal of this Society I have given an analysis of the distribution of the Acanthopterygian[1] and Siluroid[2] freshwater fishes of India, Ceylon, and Burma; and I now propose completing my inquiry by examining into what obtains in the families SCOMBRESOCIDÆ, CYPRINODONTIDÆ, CYPRINIDÆ, NOTOPTERIDÆ, and SYMBRANCHIDÆ.

Family SCOMBRESOCIDÆ.

One freshwater form is found amongst the Indian genera.

1. BELONE[3], *Cuvier*. Tropical and temperate seas; some species inhabiting fresh waters.

Genus BELONE.

1. B. CANCILA[4], *Ham. Buch.* Sind, India, Ceylon, and Burma.

[1] Journal Linn. Soc. Zool. vol. xiii. p. 138.
[2] *L. c.* p. 338.
[3] Includes:—*Mastacembelus* (Klein), Bleeker; *Rhamphistoma*, Raff.; *Tylosurus*, Cocco; *Potamorrhaphis*, Günther.
[4] Includes *Belone Grayii*, Sykes.

Family CYPRINODONTIDÆ.

Two genera of this family have representatives in India, as follows:—

1. CYPRINODON[1], *Lacépède.* This genus is distributed through Southern Europe, North Africa, Syria, Persia, along the shores of the Red Sea, and is also found in Cutch[2].

2. HAPLOCHILUS[3], *M'Clelland.* India to the Malay archipelago and beyond, tropical Africa, Madagascar, and islands of the Indian Ocean. Also temperate and tropical America.

These small fishes as found in India are mostly inhabitants of waters within the influence of tides or along the deltas of large rivers; some, however, reside in streams on hills, as the western Ghauts and Sind hills.

The distribution of the species is as follows:—

Genus CYPRINODON.

1. C. DISPAR[4], *Rüppell.* Abyssinia, Palestine, shores of the Red Sea, Cutch.

Genus HAPLOCHILUS.

1. H. MELASTIGMA[5], *M'Clelland.* From the Wynaad on the western coast of India, up the Coromandel coast to Orissa, Lower Bengal, and Burma.

2. H. RUBROSTIGMA[6], *Jerdon.* Malabar coast of India and southern portions of the Coromandel coast.

[1] Includes:—*Lebias*, Cuvier; *Aphanias*, Nardo; *Micromugil*, Gulia.

[2] In considering Cutch as India, I must remark that it at one time must have been west of the river Indus, which river, as observed by Balfour (Cyclopædia of India), "flows through the three parts (districts of Sind), and at some comparatively recent time it has changed its bed; but the old bed still exists under the name of Nara, and its course has been surveyed from the ruins of Alor to the Run of Cutch. From Alor to Jakrao, a distance of 100 miles, its direction is nearly due south. It there divides into several channels, each bearing a separate name. The most easterly channel, which retains the name of Nara, runs to the south-east by Kipra and Umrkot, near which it turns to the south-west by Wanga Bazar and Romaka Bazar, and is there lost in the great Run of Cutch."

[3] Includes:—*Aplocheilus*, M'Clelland; *Panchax*, Cuv. & Val.; *Zygonectes*, Agassiz; *Micristius*, Gill.

[4] Includes:—*Cyprinodon lunatus*, Cuv. & Val.; *C. hammonia*, Richardson; *C. Stoliczkanus*, Day.

[5] Includes:—*Aplocheilus M'Clellandi*, Bleeker; *Aplocheilus carnaticus*, Jerdon; *Panchax cyanophthalmus*, Blyth; *Haplochilus argenteus*, Day.

[6] Perhaps includes *Aplocheilus affinis*, Jerdon.

3. H. LINEATUS[1], *Cuv. & Val.* Western Ghauts and Malabar coast to Ceylon.

4. H. PANCHAX[2], *Ham. Buch.* Orissa, Lower Bengal, Burma, Siam, Andaman Islands to the Malay archipelago.

Amongst the CYPRINIDÆ we know of thirty-five genera represented in the fresh waters of India, Burma, and Ceylon; of these, twenty-six belong to the true Carps (*Cyprinina*), and nine to the Loaches (*Cobitidina*).

Of the *Cyprinina*, or true Carps, including the *Homalopterina*, we find the following:—

1. HOMALOPTERA[3], *v. Hasselt.* This genus is distributed through some of the hilly districts of the Himalayas, also the western Ghauts and Neilgherries in the Madras Presidency; and examples are likewise found in Java and Sumatra.

2. PSILORHYNCHUS, *M'Clelland.* Hill-streams and rivers in Bengal and Assam.

3. DISCOGNATHUS[4], *Heckel.* Rivers, more especially mountain-streams, of Asia and Abyssinia, extending throughout India, Ceylon, and the Tenasserim provinces.

The next and four succeeding genera consist of a division of Carps which are strictly residents of hilly regions of the Himalayas, but some descend to the plains.

4. OREINUS, *M'Clelland.* This genus extends from the Helmund river and Jellalabad in Afghanistan,along the Himalayan and contiguous ranges of mountains to at least the confines of China. They only descend a short distance into the rivers of the plains, and are absent from the level plateaux on the summit of those mountains.

5. SCHIZOPYGOPSIS, *Steindachner.* Cold regions of the Himalayas about the head-waters of the Indus, Tibet, and Eastern Turkestan, where the rivers are snow-fed. In short, the Schizothoracina (if we exclude the Himalayan *Oreinus*) are confined to cold regions, or at least to localities possessing snow-fed rivers, many

[1] Includes *Aplocheilus vittatus*, Jerdon.

[2] Includes:—*Aplocheilus chrysostigmus*, M'Clelland; *Panchax Buchanani* and *Kuhlii*, Cuv. & Val.; *P. melanopterus*, Bleeker.

[3] Includes:—*Balitora*, Gray; *Platycara*, pt., M'Clelland; *Octonema*, Martens.

[4] Includes:—*Garra*, Hamilton Buchanan; *Platycara*, pt., M'Clelland; *Discognathichthys* and *Lissorhynchus*, Bleeker: *Mayoa*, Day.

of which rivers terminate in lakes which have no communication with any sea.

6. Schizothorax, *Heckel*. A Himalayan genus extending to Afghanistan and Turkestan.

7. Ptycobarbus, *Steindachner*. Himalayas as head-waters of the Indus; also Tibet and Kashgar.

8. Diptychus, *Steindachner*. Upper Himalayan region, as Nepaul and Tibet to Yarkand.

9. Labeo[1], *Cuvier*. This genus is spread from tropical Africa and Syria throughout the fresh waters of India, Ceylon, and Burma, to the Malay archipelago and beyond.

10. Osteochilus, *Günther*. Burma and the Malay archipelago.

11. Dangila, *Cuvier & Valenciennes*. Burma to the Malay archipelago.

12. Cirrhina[2], *Cuvier & Valenciennes*. From Beloochistan, Sind, and India, through Burma to the Malay archipelago.

13. Semiplotus, *Bleeker*. Assam and Chittagong hill-ranges to Burma.

14. Scaphiodon[3], *Heckel*. This genus is closely allied to the last, but its dorsal fin is of less extent. Rivers of Syria and Western Asia, extending to those of Sind and the Punjab; also along the western Ghauts as far south as the Neilgherry hills and rivers along their bases.

15. Catla[4], *Cuvier & Valenciennes*. Sind and the Punjab, N.W. Provinces, the Deccan, throughout Bengal, Assam, Burma, and Siam, but appears to be absent from Southern India below the Kistna river.

16. Thynnichthys[5], *Bleeker*. Throughout the Kistna and Godavery rivers in India from the Deccan to their terminations; also the Malay archipelago.

[1] *Bangana*, pt., Ham. Buch.; *Rohita*, pt., Cuv. & Val.; *Tylognathus*, Heckel; *Nandina*, Gray; *Hypselobarbus*, *Diplocheilus*, *Diplocheilichthys*, *Labocheilus*, *Rohitichthys*, *Morulius*, *Schismatorhynchus*, and *Gobionichthys*, Bleeker; *Gobiobarbus*, Dybowski.

[2] *Bangana*, pt., Ham. Buch.; *Dangila*, pt., Cuv. & Val.; *Crossochilus*, pt., Günther.

[3] *Capoëta* (Cuv. & Val.), Günther.

[4] *Gibelion*, Heckel; *Hypselobarbus*, Bleeker.

[5] *Mola*, pt., Blyth.

17. AMBLYPHARYNGODON[1], *Bleeker*. From Sind, throughout the plains of India, Ceylon, and Burma.

18. BARBUS[2], *Cuv. & Val.* This most extensive genus is found distributed throughout Europe, Asia, and Africa, about seventy species existing in India, Ceylon, and Burma.

19. NURIA[3], *Cuv. & Val.* Continent of India, Ceylon, Burma, and the Nicobars.

20. RASBORA[4], *Bleeker*. Africa, Sind, continent of India, Ceylon, Burma, to the Malay archipelago.

21. ASPIDOPARIA[5] (*Heckel*), *Bleeker*. Sind, India (except south of the Kistna), Assam, and Burma.

22. ROHTEE[6], *Sykes*. Sind, continent of India and Burma.

23. BARILIUS[7], *Hamilton Buchanan*. From the Nile and East Africa; also Afghanistan; throughout Sind, India, Ceylon, Assam, and Burma, extending to the Malay archipelago.

24. DANIO[8], *Hamilton Buchanan*. Sind, throughout India, Ceylon, Assam, and Burma.

25. PERILAMPUS[9], *M'Clelland*. Sind, throughout India, Ceylon, Assam, and Burma.

26. CHELA[10], *Hamilton Buchanan*. Sind, throughout India, Assam, and Burma, to the Malay archipelago.

Of the second division of Indian Carps, the *Cobitidina* or Loaches, we have examples of the following genera.

[1] Includes :—*Mola*, Heckel; *Brachygramma*, Day.

[2] Includes :—*Puntius*, pt., Ham. Buch.; *Labeobarbus*, *Varicorhinus*, pt., Rüppell; *Systomus*, pt., M'Clelland; *Capoëta*, sp., Cuv. & Val.; *Pseudobarbus*, Bietz.; *Luciobarbus*, Heckel; *Cheilobarbus*, sp., Smith; *Balantiocheilus*, *Hemibarbus*, *Cyclocheilichthys*, *Siaja*, *Anematichthys*, *Hypselobarbus*, *Gonoproktopterus*. *Gnathopogon*, *Hampala*, sp., Bleeker; *Enteromius*, sp., Cope.

[3] Includes *Esomus*, Swainson.

[4] Includes *Megarasbora*, Günther.

[5] Includes *Morara*, Bleeker.

[6] Includes :—*Osteobrama*, Heckel; *Smiliogaster*, Bleeker.

[7] Includes :—*Opsarius*, sp., M'Clelland; *Pachystomus*, Heckel; *Chedrus*, Swainson; *Schacra*, Bleeker; *Opsaridium*, Peters; *Pteropsarion* and *Bola* (not H. B.), Günther.

[8] Includes :—*Perilampus*, sp., M'Clelland; *Paradanio* and *Devario*, Bleeker.

[9] Includes :—*Chela*, Swainson; *Laubuca*, Bleeker; *Cachius* and *Eustira*, Günther.

[10] Includes :—*Oxygaster*, v. Hass.; *Salmophasia*, Swainson; *Macrochirichthys* and *Paralaubuca*, Bleeker.

27. BOTIA[1], *Gray*. Sind hills, delta of the Ganges, the Himalayas, Assam, Burma to the Malay archipelago.

28. ACANTHOPSIS[2], *v. Hasselt*. Burma to the Malay archipelago.

29. SOMILEPTES (*Swainson*), *Bleeker*. From Orissa and Bengal to Assam.

30. LEPIDOCEPHALICHTHYS[3], *Bleeker*. India, Ceylon, and Burma, to the Malay archipelago.

31. ACANTHOPHTHALMUS[4], *v. Hasselt*. North-east Bengal, Assam, and Burma.

32. APUA, *Blyth*. Pegu in British Burma.

33. JERDONIA, *Day*. Madras.

34. NEMACHEILICHTHYS, *Day*. Deccan.

35. NEMACHEILUS[5], *v. Hasselt*. Europe, Western Asia, Turkestan, throughout India, Assam, Ceylon, and Burma, to the Malay archipelago. It is remarkable that those from the upper parts of the Himalayas and Western Turkestan are destitute of scales.

Examining the foregoing genera composing the Carps of India, we find 14 reach the Malay archipelago, 5 Africa, 4 of which are identical with genera extending to the Malay archipelago; while 5 are restricted to the colder regions of the Himalayas, extending to Turkestan.

I will now follow out the distribution of each species which are included in the foregoing genera.

Subfamily CYPRININA.

Genus HOMALOPTERA.

1. H. BRUCEI[6], *Gray*. Himalayas from round Darjeeling through Boutan, Assam, and the Khasia hills: also the Wynaad and Bowany rivers in Madras.

[1] Includes:—*Hymenophysa* and *Schistura*, M'Clelland; *Diacanthus*, Swainson; *Syncrossus*, Blyth.

[2] Includes *Prostheacanthus*, Blyth.

[3] Includes:—*Platacanthus*, Day; *Misgurnus*, sp., Günther.

[4] Includes *Pangio*, Blyth.

[5] Includes:—*Acoura* and *Acourus*, Swainson; *Acanthocobitis*, Peters; *Oreias*, Sauvage; *Diplophysa*, Kessler.

[6] Includes *Platycara australis*, Jerdon.

2. H. maculata[1], *Gray*. Himalayas, also the Wynaad and Bowany rivers in Madras.

3. H. bilineata[2], *Blyth*. Tenasserim Provinces.

Genus Psilorhynchus.

1. P. balitora[3], *Ham. Buch.* Hill-streams and rapids in Northern Bengal and Assam.

Genus Discognathus.

1. D. lamta[4], *Ham. Buch.* From Syria throughout India and Ceylon to the Tenasserim Provinces; also Aden and Abyssinia.

2. D. Jerdoni, *Day*. Wynaad and Neilgherry hill-streams and rivers at their bases.

3. D. modestus, *Day*. Probably Northern India or Assam.

Genus Oreinus.

1. O. sinuatus[5], *Heckel*. From Afghanistan along the Himalayas.

2. O. Richardsonii[6], *Gray*. Himalayas.

3. O. plagiostomus[7], *Heckel*. Himalayas.

Genus Schizopygopsis.

1. S. Stoliczkæ, *Steindachner*. Himalayas to the Yarkand and Oxus rivers.

Genus Schizothorax.

1. S. progastus[8], *M'Clelland*. Himalayas.

2. S. esocinus, *Heckel*. Himalayas.

[1] Includes *Platycara anisura*, M'Clelland.

[2] Perhaps identical with *Cyprinus sucatio*, Ham. Buch., from rivers of Northern Bengal.

[3] Includes *Psilorhynchus variegatus*, M'Clelland.

[4] Includes:—*Cyprinus gotyla*, Gray; *Gonorhynchus rupeculus*, *bimaculatus*, *brachypterus*, and *caudatus*, M'Clelland; *Chondrostoma mullya*, Sykes; *Platycara nasuta*, and ? *lissorhynchus*, M'Clelland; *Discognathus rufus*, *obtusus*, *crenulatus*, and *fusiformis*, Heckel; *Platycara notata*, Blyth; *Gonorhynchus M'Clellandi* and *stenorhynchus*, Jerdon; *Garra ceylonensis*, Bleeker; *G. malabarica* and *alta*, Day; *Discognathus macrochir*, Günther.

[5] Includes *Oreinus maculatus*, M'Clelland.

[6] Includes:—*Oreinus guttatus* and *Gonorhynchus petrophilus*, M'Clelland; *Oreinus maculatus*, Günther.

[7] Includes *Capoëta micracanthus*, Günther.

[8] Inlcudes *Oreinus Hodgsonii*, Günther.

Genus Ptycobarbus.

1. P. conirostris, *Steindachner*. Himalayas.

Genus Diptychus.

1. D. maculatus[1], *Steindachner*. Himalayas and affluents of Yarkand river.

Genus Labeo.

1. L. nandina[2], *Ham. Buch.* Bengal, Assam, and Burma.

2. L. fimbriatus[3], *Bloch.* Sind, Punjab, Deccan, N.E. Bengal, Orissa to Southern India, but not Malabar.

3. L. nigrescens, *Day.* Malabar coast.

4. L. calbasu[4], *Ham. Buch.* Throughout Sind, the Punjab, India, and Burma.

5. L. Stoliczkæ[5], *Steindachner.* Irrawaddi and Salwein rivers in Burma.

6. L. gonius[6], *Ham. Buch.* Sind, and from the Punjab, throughout India (except south of the river Kistna), Assam, and Burma.

7. L. Dussumieri[7], *Cuv. & Val.* Rivers along the western coast of India and Ceylon.

8. L. rohita[8], *Ham. Buch.* From Sind and the Punjab throughout India (except south of the Kistna and the Malabar coast), Assam and Burma.

9. L. porcellus, *Heckel.* Poona and Bombay.

10. L. potail, *Sykes.* Deccan.

11. L. kontius[9], *Jerdon.* Southern India.

12. L. cæruleus, *Day.* River at base of Beloochistan hills in Sind.

[1] Includes ? *D. Sewerzowi*, Kessler.

[2] Includes *Cirrhinus macronotus*, M'Clelland.

[3] Includes :—*Cyprinus nancar*, Ham. Buch.; *Rohita Leschenaultii*, Cuv. & Val.; *Varicorhinus bobree*, Sykes.

[4] Includes :—*Cirrhina micropogon*, Val.; *Rohita Belangeri* and *Reynauldi*, Cuv. & Val.; *Labeo velatus*, Val.; *Cirrhinus affinis*, Jerdon.

[5] Perhaps identical with *Labeo Reynauldi*, Cuv. & Val.

[6] Includes :—*Cyprinus curchius, cursa*, and *cursis*, Ham. Buch.; *Labeo microlepidotus*, Cuv. & Val.

[7] Includes *Rohita Rouxii*, Cuv. & Val.

[8] Includes :—*Rohita Buchanani* and *Duvaucelii*, also *Labeo fimbriatus* and *Dussumieri*, Cuv. & Val.

[9] Includes *Cirrhinus rubro-punctatus*, Jerdon.

13. L. DIPLOSTOMUS[1], *Heckel.* Along the hills of Sind and the Himalayas, including the rivers at their bases.

14. L. DYOCHEILUS[2], *M'Clelland.* Sind hills, Himalayas to Assam.

15. L. PANGUSIA, *Ham. Buch.* Sind, the Himalayas, delta of the Ganges, Deccan, Cachar, and Assam.

16. L. ANGRA[3], *Ham. Buch.* Orissa, Bengal, and Assam.

17. L. BATA[4], *Ham. Buch.* Lower Bengal and Assam, extending as far south as the river Kistna.

18. L. MICROPHTHALMUS[5], *Day.* Himalayas.

19. L. BOGGUT[6], *Sykes.* From the Punjab throughout India (except Sind, the western coast, and Assam).

20. L. BOGA[7], *Ham. Buch.* Rivers of Gangetic Provinces, Madras, and Burma.

21. L. NUKTA, *Sykes.* The Deccan.

22. L. NIGRIPINNIS, *Day.* Sind hills and rivers along their bases.

23. L. SINDENSIS, *Day.* Sind, the Punjab, and the Deccan.

24. L. ARIZA[8], *Ham. Buch.* Western Ghauts of Madras and rivers near their bases.

25. L. KAWRUS, *Sykes.* Deccan.

The foregoing 25 species are thus distributed:—3 Sind and Himalayas, one of which species extends to Assam; 2 Sind; 1 Sind, Punjab, and Deccan; 1 Sind, India (except the south), and Assam; 1 Sind and India, except Malabar; 2 Sind, India (except Malabar), and Burma; 1 delta of Ganges: 2 Lower Bengal, Orissa, and Assam; 1 delta of Ganges and Brahmapootra to

[1] Includes:—(? *Cyprinus dero*, Ham. Buch.); *Cyprinus falcata*, Gray; *Gobio malacostomus* and *ricnorhynchus*, M'Clelland; *Tylognathus Valenciennesii*, Heckel.

[2] Includes:—(? *Gobio bicolor*, M'Clelland); *Labeo falcatus*, Günther.

[3] Includes:—(? *Cyprinus morala*, *pausius*, and *musiha*, Ham. Buch.); *Cyprinus Hamiltonii*, Gray; *Gobio boga*, Bleeker.

[4] Includes:—*Cyprinus acra* and *cura*, Ham. Buch.; *Gobio lissorhynchus* and *anisurus*, M'Clelland.

[5] Includes *Labeo diplostomus*, Beavan.

[6] Includes *Tylognathus striolatus*, Günther.

[7] Includes:—? *Cyprinus falcatus*, Bloch, and *Chondrostoma semivelatus*, Cuv. & Val.

[8] Includes *Gobio Hamiltonii* and *Bovianus*, Jerdon.

Burma; 1 delta of Ganges, Madras, and Burma; 1 Burma; 4 Deccan and Bombay; 2 Malabar and western Ghauts; 1 Malabar and Ceylon; 1 South India; 1 Burma.

Genus Osteochilus.

1. O. chalybeatus[1], *Cuv. & Val.* Burma.

2. O. neilli, *Day.* Burma.

3. O. cephalus, *Cuv. & Val.* Pegu in Burma.

Genus Dangila.

1. D. burmanica, *Day.* Moulmein and Tavoy.

2. D. Berdmorei, *Blyth.* Tenasserim Provinces.

Genus Cirrhina.

1. C. cirrhosa[2], *Bloch.* From the Godavery and Kistna, throughout Southern India.

2 C. mrigala[3], *Ham. Buch.* Sind and the Punjab, throughout India, except its southern portion, also Burma.

3. C. latia[4], *Ham. Buch.* Sind and the Punjab, throughout India, except its southern portion, also along the Himalayas.

4. C. reba[5], *Ham. Buch.* Throughout India and Assam.

5. C. fulungee, *Sykes.* Deccan.

Genus Semiplotus.

1. S. modestus, *Day.* Hill-ranges above Akyab.

2. S. Macclellandi, *Bleeker.* Rivers in Assam as low as Goalpara; also found in Burma.

[1] Includes *Rohita lineata*, Cuv. & Val.

[2] Includes :—*Dangila Leschenaultii* and *Cirrhina Blochii*, Cuv. & Val.; *Cirrhinus Cuvierii*, Jerdon; *Cirrhina macrops*, Steindachner.

[3] Includes :—*Cirrhina rubripinnis* and *plumbea*, Cuv. & Val.; *Mrigala Buchanani*, Bleeker.

[4] Includes :—*Cyprinus gohama* (and ? *C. sada*), Ham. Buch.; *Barbus diplochilus* and *Tylognathus barbatulus*, Heckel; *Gonorhynchus fimbriatus*, *macrosomus* and *brevis*, M'Clelland; *Chondrostoma wattanah*, Sykes; *Crossochilus rostratus*, Günther.

[5] Includes :—*Gobio isurus* and *limnophilus*, M'Clelland; *Chondrostoma gangeticum* and *Cirrhina Dussumieri*, Cuv. & Val.; *Cirrhina bengalensis*, Bleeker; *Cirrhina rewah*, Steindachner.

Genus Scaphiodon.

1. S. Watsoni, *Day*. Sind hills and the Punjab.

2. S. irregularis, *Day*. Sind hills.

3. S. Thomassi, *Day*. South Canara.

4. S. Nashii, *Day*. Coorg, South Canara and the Wynaad.

5. S. brevidorsalis, *Day*. Rivers at base of Neilgherry hills.

Of the foregoing 5 species, 1 is restricted to Sind, 1 to Sind and the Punjab, 1 to South Canara, 1 to the western Ghauts, and 1 to the rivers at the base of the Neilgherry hills.

Genus Catla.

1. C. Buchanani[1], *Cuv. & Val.* Sind, the Punjab, India except its southern portion, Assam, Burma, and Siam.

Genus Thynnichthys.

1. T. sandkhol[2], *Sykes*. Godavery and Kistna rivers and adjacent pieces of water.

Genus Amblypharyngodon.

1. A. Atkinsonii[3], *Blyth*. Burma.

2. A. mola[4], *Ham. Buch.* From Sind, throughout India (except the Malabar coast), Assam, and Burma.

3. A. microlepis[5], *Bleeker*. From the Hooghly through Orissa, and down the Coromandel coast as far south as Madras.

4. A. melettinus[6], *Cuv. & Val.* Malabar coast and Southern India to Madras; also Ceylon.

Of the foregoing 4 species, 1 extends from Sind throughout India (except the Malabar coast) to Assam and Burma; 1 from Lower Bengal down the Coromandel coast to Madras; 1 the Malabar coast, Ceylon, and up the Coromandel coast to Madras; 1 Burma. Thus every portion of the plains of India and Burma

[1] Includes *Cyprinus abramioides*, Sykes.

[2] Includes *Thynnichthys cochinensis*, Günther.

[3] Includes probably *Leuciscus harengula*, Cuv. & Val.

[4] Includes :—(? *Leuciscus chitul*, Sykes); *Mola Buchanani*, Blyth; (? *Rhodeus macrocephalus*, Jerdon).

[5] Includes :—(*Leuciscus pellucidus*, M'Clelland); *Amblypharyngodon pellucidus*, Günther.

[6] Includes :—*Rhodeus indicus*, Jerdon; *Amblypharyngodon Jerdoni*, Day.

is seen to possess one or other species of this genus. At several points of junction we perceive two forms which are as distinct from one another as they are when at their greatest distance apart.

Genus Barbus.

(a) *With 4 barbels.* (Barbodes.)

1. B. chagunio[1], *Ham. Buch.* From the Punjab, through the Gangetic valley to Lower Bengal and Orissa, also Assam.

2. B. clavatus, *M'Clelland.* Base of Himalayas, near Sikhim.

3. B. sarana[2], *Ham. Buch.* Throughout the plains of Sind, India, Assam, and Burma.

4. B. chrysopoma[3], *Cuv. & Val.* Throughout the plains of Cutch and India; also from the Himalayas, near Darjeeling.

5. B. pinnauratus[4], *Day.* Western coast of India to Ceylon and up the Coromandel coast certainly as high as Coconada.

6. B. pleurotænia, *Bleeker.* Ceylon.

7. B. goniosoma, *Bleeker.* Mergui and Sumatra.

8. B. roseipinnis, *Cuv. & Val.* Pondicherry.

9. B. dubius, *Day.* Bowany River, at base of Neilgherry hills.

10. B. micropogon[5], *Cuv. & Val.* Malabar coast and western Ghauts, also Mysore.

11. B. chilinoides[6], *M'Clelland.* Himalayas, extending as far east as Assam, and descending into the Ganges.

12. B. carnaticus, *Jerdon.* Rivers along the bases of the western Ghauts and Neilgherry hills.

13. B. hexagonolepis, *M'Clelland.* Assam.

14. B. dukai, *Day.* Teesta River, Darjeeling.

[1] Includes:—*Barbus spilopholus* and *sarana* (not H. B.), M'Clelland; *Barbus Beavani*, Günther.

[2] Includes:—*Cyprinus kunnamoo, kakoo*, and *kadoon*, Russell; *Barbus deliciosus, Systomus immaculatus* and *chrysostomus*, M'Clelland; *B. gardinodes* and *Duvaucelli, Cyprinus M'Clellandi*, Cuv. & Val.; *Barbus caudimarginatus*, Blyth; *B. Russelli*, Günther.

[3] Probably identical with *Barbus Polydori*, Bleeker.

[4] Includes:—(? *Barbus nasutus* and *subnasutus*, Cuv. & Val.); *Puntius chrysopoma* (not C. & V.), Bleeker; *Barbus spilurus*, Günther.

[5] Includes *Barbus gracilis* and *mysorensis*, Jerdon; *B. conirostris*, Günther.

[6] Includes:—*Labeobarbus mosal* (not H. B.), Steindachner; *Barbus micropogon* (not C. & V.), Günther; *B. himalayanus*, Day.

15. B. TOR[1], *Ham. Buch.* Throughout Sind, India, and Assam, but most abundant and largest in size near mountain-streams.

16. B. HEXASTICHUS, *M'Clelland.* Rivers on and around the Himalayas.

17. B. BOVANICUS, *Day.* Bowany River, at base of Neilgherry hills.

18. B. SOPHORE, *Ham. Buch.* Assam and Khasia hills.

19. B. STRACHEYI, *Day.* Akyab and Moulmein.

20. B. CURMUCA[2], *Ham. Buch.* Western Ghauts of India.

21. B. LITHOPIDOS, *Day.* South Canara.

22. B. THOMASSI, *Day.* South Canara.

23. B. SPINULOSUS, *M'Clelland.* Sikhim.

24. B. PULCHELLUS, *Day.* South Canara.

25. B. DOBSONI, *Day.* Deccan.

26. B. JERDONI, *Day.* South Canara.

27. B. WYNAADENSIS, *Day.* Wynaad.

28. B. STEPHENSONII, *Day.* Hills near Akyab.

29. B. NEILLI[3], *Day.* Tamboodra river at Kurnool.

30. B. MALABARICUS, *Jerdon.* Western Ghauts of India, extending as far south as Courtallum.

31. B. INNOMINATUS[4], *Day.* Ceylon.

32. B. COMPRESSUS, *Day.* Cashmere ?

33. B. BLYTHII[5], *Day.* Tenasserim.

34. B. MELANAMPYX[6], *Day.* From the Wynaad down the western Ghauts of India and rivers along their bases.

(b) *With 2 barbels.* (CAPOËTA.)

35. B. MACROLEPIDOTUS, *Cuv. & Val.* Tavoy to the Malay archipelago.

[1] Includes:—*Cyprinus mosal* and (? *putitora*), Ham. Buch.; *Labeobarbus microlepis*, Heckel; *Barbus progeneius*, *megalepis*, and *macrocephalus*, M'Clelland; *B. mussulah*, Sykes; *B. Hamiltonii*, Jerdon.

[2] Includes *Gobio canarensis*, Jerdon.

[3] Perhaps includes *Barbus khudree*, Sykes.

[4] Includes *Leuciscus binotatus*, Blyth (not K. & v. Hass.).

[5] Includes *Capoëta macrolepidota*, Blyth (not C. & V.).

[6] Includes:—*Cirrhinus fasciatus*, Jerdon (not Bleeker); *Barbus Grayi*, Day; *B. arulius*, Günther (not Jerdon).

36. B. CHOLA[1], *Ham. Buch.* Throughout India, Assam, and Burma, as far as Mergui.

37. B. PARRAH, *Day.* Malabar, Mysore, and Madras.

38. B. BURMANICUS, *Day.* Mergui in Burma.

39. B. TETRARUPUGUS[2], *M'Clelland.* Sind, India (except south of the Kistna), and Assam.

40. B. DORSALIS[3], *Jerdon.* Southern India south of the Deccan and Ceylon.

41. B. KOLUS[4], *Sykes.* Central provinces, Deccan, and throughout the Kistna, Tamboodra, and Godavery rivers.

42. B. DENISONII, *Day.* Travancore hill-ranges.

43. B. MELANOSTIGMA[5], *Day.* Wynaad and Neilgherry hills, and rivers at their bases.

44. B. ARENATUS, *Day.* Madras.

45. B. PUCKELLI, *Day.* Mysore.

46. B. AMPHIBIUS[6], *Cuv. & Val.* Central India and the Deccan; the Western coast of India from Bombay to Cape Comorin and up the Eastern so far as Orissa.

47. B. ARULIUS[7], *Jerdon.* Wynaad and Neilgherry hills and western Ghauts as far south as Travancore; also rivers along their bases.

48. B. MAHECOLA[8], *Cuv. & Val.* From Canara down the western coast, also Ceylon; likewise along the lower part of the Coromandel coast.

(c) *Without barbels.* (PUNTIUS.)

49. B. APOGON[9], *Cuv. & Val.* Burma to the Malay archipelago.

[1] Includes:—*Systomus immaculatus*, Blyth; *Puntius perlee*, Day; *Barbus liacanthus*, pt., *sophoroides*, and *thermalis* (not C. & V.), Günther.

[2] Probably includes *Cyprinus titius* and *tictis*, Ham. Buch.

[3] Includes:—(? *Systomus tristis*, Jerdon); *Barbus tetraspilus* and *Layardi*, Günther.

[4] Includes *Barbus Guentheri*, Day.

[5] Includes *Systomus carnaticus*, Jerdon.

[6] Includes *Puntius Hamiltonii*, Day.

[7] Includes *Systomus rubrotinctus*, Jerdon.

[8] Includes *Barbus filamentosus*, Günther (not C. & V.).

[9] Includes:—*Systomus apogonoides*, Bleeker; *S. macularius*, Blyth.

50. B. AMBASSIS, *Day.* Assam, Lower Bengal, along the Coromandel coast to Madras.

51. B. CONCHONIUS[1], *Ham. Buch.* Punjab, the Deccan, deltas of the Ganges and Brahmapootra.

52. B. TICTO[2], *Ham. Buch.* Sind, and throughout India and Ceylon.

53. B. STOLICZKANUS[3], *Day.* Eastern Burma.

54. B. PUNCTATUS[4], *Day.* Malabar and Coromandel coast.

55. B. GELIUS[5], *Ham. Buch.* Ganjam, Orissa, Lower Bengal, and Assam.

56. B. PHUTUNIO[6], *Ham. Buch.* Ganjam, Orissa, Bengal, and Burma.

57. B. CUMINGII[7], *Günther.* Ceylon.

58. B. NIGROFASCIATUS, *Günther.* Southern Ceylon.

59. B. GUGANIO, *Ham. Buch.* Gangetic provinces and Assam.

60. B. STIGMA[8], *Cuv. & Val.* Sind, throughout India, Assam, and Burma.

61. B. CHRYSOPTERUS, *M'Clelland.* Sind, delta of Ganges, Assam.

62. B. THERMALIS, *Cuv. & Val.* Ceylon.

63. B. TERIO[9], *Ham. Buch.* Delta of the Ganges from the Punjab to Lower Bengal, also Orissa.

64. B. PUNJAUBENSIS, *Day.* Punjab and Sind.

65. B. UNIMACULATUS, *Blyth.* Burma.

66. B. WAAGENI, *Day.* Punjab.

67. B. COSUATIS[10], *Ham. Buch.* Delta of the Ganges, Central India, the Deccan, and from Bombay down the western coast to Cottayam.

[1] Includes *Systomus pyrrhopterus*, M'Clelland.

[2] Includes *Systomus tripunctatus*, Jerdon.

[3] Includes *Barbus M'Clellandi*, Day (not Cuv. & Val.).

[4] Includes *Systomus conchonius*, Jerdon (not H. B.).

[5] Includes *Cyprinus canius*, Ham. Buch.

[6] Includes *Systomus leptosomus*, M'Clelland.

[7] Includes *Puntius phutunio*, Bleeker (not H. B.).

[8] Includes :—*Cyprinus sophore*, pt., Ham. Buch. ; *Systomus sophore*, M'Clelland ; *Leuciscus Duvaucelii* and *sulphureus*, Cuv. & Val. ; *Puntius modestus*, Kner.

[9] Includes *Systomus gibbosus*, M'Clelland.

[10] Includes :—*Systomus malacopterus*, M'Clelland ; *Rohtee pangut*, Sykes.

68. B. VITTATUS[1], *Day.* Cutch, Southern India, Malabar coast, and Ceylon.

69. B. FILAMENTOSUS[2], *Cuv. & Val.* Canara, Malabar coast, and Southern India.

70. B. PUNTIO, *Ham. Buch.* Bengal and British Burma.

Amongst the foregoing 70 species of *Barbus*, we find 6 restricted to the Himalayas and rivers near their bases; 10 to the Gangetic delta and Assam, or Orissa, some likewise being found in Sind; 2 restricted to Sind and the Punjab; 2 to Assam; 5 extend from Bengal, or Assam to Burma; 6 local to Burma; 3 Burma and the Malay archipelago; 2 throughout India; 1 from Central to South India; 1 Lower Bengal down the Coromandel coast to Madras; 3 Deccan; 6 Mysore and Southern India; 11 Western coast and Ghauts; 4 Western coast and South India; 3 Western coast, South India, and Ceylon; 5 Ceylon. Thus we find 2 species generally distributed; 25 found in the deltas of the Indus, Ganges, or Brahmaputra, of which 5 extend to Burma; 9 more are found in Burma; 1 species from Bengal to Madras; 10 from Central and Southern India; 18 from the Western coast, some of which are likewise found in Southern India and 3 in Ceylon, whilst 5 are peculiar to that island. Out of 14 of the above species found in Burma, 3 (none of which are found in India) extend to the Malay archipelago.

Genus NURIA.

1. N. DANRICA[3], *Ham. Buch.* India, Ceylon, Burma, and the Nicobars.

Genus RASBORA.

1. R. ELANGA[4], *Ham. Buch.* Gangetic delta, Assam, and Burma.

2. R. DANICONIUS[5], *Bleeker.* West coast of Africa, continent of India, Ceylon to the Malay archipelago.

3. R. BUCHANANI[6], *Bleeker.* Continent of India, Assam, and Burma to Pinang.

[1] Includes *Puntius sophore*, Kner.

[2] Includes *Systomus assimilis* and *madraspatensis*, Jerdon.

[3] Includes:—*Cyprinus sutiha* and *jogia*, Ham. Buch.; *Perilampus recurvirostris*, *macrurus* and *thermophilus*, M'Clelland; *Esomus vittatus*, Swainson; *Nuria alta*, Blyth; *Esomus malabaricus* and *madraspatensis*, Day.

[4] Includes *Leuciscus dystomus*, M'Clelland.

[5] Includes:—*Cyprinus anjana*, Ham. Buch.; *Leuciscus rasbora* and *lateralis*, M'Clelland; *L. dandia*, Cuv. & Val.; *L. malabaricus*, *Caverii*, and *flavus*, Jerdon; *Rasbora woolaree* and *neilgherriensis*, Day.

[6] Includes:—*Cyprinus rasbora*, Ham. Buch.; *Leuciscus presbyter*, Cuv. & Val.; *L. xanthogramme* and *microcephalus*, Jerdon.

In the 3 species of this genus, we find 1 extends from the Gangetic delta to Assam and Burma; 1 from Africa, through India and Ceylon, to the Malay archipelago; 1 throughout India to Pinang. The last two with such a wide distribution are subject to considerable local variation; the first, with a less extended range, is less variable.

Genus Aspidoparia.

1. A. morar[1], *Ham. Buch.* Sind, India, except the western coast and its southern portion (south of the Kistna), Assam, and Burma.

2. A. jaya[2], *Ham. Buch.* Gangetic delta and Assam.

The two species forming this genus are not found along the western coast or Southern India; one extends to Burma.

Genus Rohtee.

1. R. Bakeri, *Day.* Travancore.

2. R. Neilli, *Day.* Bowany River, at base of Neilgherry hills.

3. R. cotio[3], *Ham. Buch.* Sind, throughout India (except the western coast and south of the Kistna), Assam, Burma.

4. R. Vigorsii[4], *Sykes.* Deccan, Kistna and Godavery rivers.

5. R. Belangeri[5], *Cuv. & Val.* Godavery river and Burma.

6. R. Ogilbii, *Sykes.* Deccan, Kistna and Godavery rivers.

Of the foregoing 6 species, 2 are restricted to the south portion of the western Ghauts; 2 to the Deccan and rivers going from thence to the Coromandel coast; 1 the Godavery River and Burma; 1 throughout India (except its southern portion), Assam, and Burma.

Genus Barilius.

1. B. vagra[6], *Ham. Buch.* Deltas of Indus, Ganges, and Brahmaputra; also rivers on the hills in their vicinity.

[1] Includes *Aspidoparia sardina*, Heckel.

[2] Includes *Leuciscus margarodes*, M'Clelland.

[3] Includes:—*Abramis cotis*, M'Clelland; *A. gangeticus*, Swainson; *Leuciscus Duvaucelii* and *Alfredianus*, Cuv. & Val.

[4] Includes *Osteobrama rapax* and *cotio*, Günther.

[5] Includes *Systomus microlepis*, Blyth.

[6] Includes:—*Opsarius isocheilus*, and (? *piscatorius*), M'Clelland; *Barilius alburnus*, Günther; *B. Bleekeri*, Day.

2. B. MODESTUS[1], *Day.* River Indus and its tributaries.

3. B. RADIOLATUS, *Günther.* Central India.

4. B. SCHACRA[2], *Ham. Buch.* Gangetic delta and Assam.

5. B. BENDELISIS[3], *Ham. Buch.* India, both in the hills and plains (except Sind and the Malabar coast), also Ceylon.

6. B. BARILA[4], *Ham. Buch.* Gangetic delta, Central Provinces, Orissa, and Lower Assam.

7. B. BAKERI, *Day.* Travancore hills.

8. B. GATENSIS[5], *Cuv. & Val.* Western Ghauts and Neilgherry hills.

9. B. CANARENSIS[6], *Jerdon.* Western coast.

10. B. BARNA[7], *Ham. Buch.* Deltas of Ganges and Brahmaputra, also Orissa.

11. B. GUTTATUS, *Day.* Delta of Irrawaddi from Mandalay to Prome.

12. B. TILEO[8], *Ham. Buch.* Bengal and Assam.

13. B. EVEZARDI, *Day.* Poona in the Deccan.

14. B. BOLA[9], *Ham. Buch.* Delta of Ganges and Brahmaputra, Orissa and Burma.

Of the 14 species of this genus, 5 are found in the deltas of the Ganges and Brahmaputra, 2 of which extend to Central India and Orissa; 1 is restricted to Central India; 1 to the Deccan; 1 throughout India and Ceylon (except Sind and the Malabar coast); 1 to the Indus and its tributaries; 3 to the western

[1] *Opsarius bicirrhatus*, M'Clelland, may be this species.

[2] Includes *Opsarius cirrhatus*, M'Clelland.

[3] Includes:—*Cyprinus cocsa*, *chedra*, and *tila*, Ham. Buch.; *Leucisous branchiatus*, and *elingulatus*, M'Clelland; *Cyprinus apiatus*, Val.; *Chedrus Grayi*, Swainson; *Leuciscus rubripes* and *Opsarius dualis*, Jerdon.

[4] Includes:—*Cyprinus chedrio*, Ham. Buch.; *Opsarius anisocheilus*, M'Clelland; *Bariliuis morarensis*, Günther.

[5] Includes *Barilius rugosus*, Day.

[6] Includes *Opsarius malabaricus*, Jerdon.

[7] Includes:—*Opsarius fasciatus*, *latipinnatus*, and *acanthopterus*, M'Clelland; *Barilius papillatus*, Day.

[8] Includes *Opsarius maculatus* and *brachialis*, M'Clelland.

[9] Includes:—*Cyprinus goha*, Ham. Buch.; *Opsarius gracilis* and *megastomus*, M'Clelland; *Leuciscus salmoides*, Blyth.

Ghauts; 1 to the deltas of the Ganges and Brahmaputra extending eastwards to Burma; and 1 to Burma. The fishes of this genus prefer rapid streams, and are frequently found ascending rivers of the hills.

Genus Danio.

1. D. devario[1], *Ham. Buch.* Deltas of rivers Indus, Ganges, and Brahmaputra; also Deccan.

2. D. spinosus, *Day.* Burma.

3. D. malabaricus[2], *Jerdon.* Western coast of India and Ceylon.

4. D. æquipinnatus[3], *M'Clelland.* Himalayas and rivers at their bases, Deccan, Assam, and Tenasserim.

5. D. dangila[4], *Ham. Buch.* Delta of Ganges, Himalayas, hills above Akyab.

6. D. chrysops, *Cuv. & Val.* Bengal.

7. D. neilgherriensis, *Day.* Neilgherry hills.

8. D. rerio[5], *Ham. Buch.* Lower Bengal, as far south as Maulipatam.

9. D. albolineata[6], *Blyth.* Moulmein in Burma.

10. D. nigrofasciatus, *Day.* Burma.

Of the 10 species of *Danio*, 1 is found in the deltas of the Indus, Ganges, and Brahmaputra; 2 along the Himalayas, Deccan, deltas of Ganges and Brahmaputra to Burma; 2 in Bengal; 2 along the western coast, one of which extends to Ceylon; 3 in Burma.

Genus Perilampus.

1. P. atpar[7], *Ham. Buch.* Sind, India generally, and Burma.

[1] Includes:—*Perilampus osteographus*, M'Clelland; *Devario M'Clellandi* and *cyanotænia*, Bleeker.

[2] Includes:—(? *Chela alburna*, Heckel); *Perilampus canarensis* and *mysoricus*, Jerdon; *Danio micronema* and *lineolatus*, Bleeker; *Paradanio aurolineatus*, Day.

[3] Includes *Leuciscus lineolatus* and *Perilampus affinis*, Blyth.

[4] Includes *Perilampus reticulatus*, M'Clelland.

[5] Includes:—*Cyprinus chapalio*, Ham. Buch.; *Perilampus striatus*, M'Clelland; *Danio lineatus*, Day.

[6] Includes *Danio Stoliczkæ*, Day.

[7] Includes:—*Cyprinus cachius*, Ham. Buch.; *Perilampus psilopteromus*, M'Clelland; *Chela anastoma*, M'Clelland; *Perilampus macropodus*, Jerdon; *Paradanio elegans*, Day

2. P. LAUBUCA[1], *Ham. Buch.* India (except its southern portion), Assam, and Burma.

3. P. CEYLONENSIS, *Günther.* Ceylon.

1 species found in Sind and throughout India and Burma; 1 in India (except the southern portion); and 1 in Ceylon.

Genus CHELA.

1. C. GORA[2], *Ham. Buch.* Deltas of Indus, Ganges, and Brahmaputra, also Orissa.

2. C. SLADONI, *Day.* Irrawaddi river.

3. C. SARDINELLA, *Cuv. & Val.* Burma.

4. C. UNTRAHI, *Day.* Coromandel coast of India from Orissa to the Cauvery.

5. C. ARGENTEA[3], *Day.* Rivers in Mysore and Southern India.

6. C. PUNJABENSIS, *Day.* River Indus and its tributaries.

7. C. PHULO[4], *Ham. Buch.* India (except its southern portion and western coast); also Assam.

8. C. BOOPIS[5], *Day.* Western coast.

9. C. CLUPEOIDES[6], *Bloch.* Cutch, Central and Southern India (not Malabar), Burma.

10. C. BACAILA[7], *Ham. Buch.* India, except Malabar, Mysore, and Madras; also Burma.

Of the foregoing 10 species, 2 are extended throughout India and Assam (except Malabar and South India), one of which reaches Burma; 1 from Cutch through Central and Southern India (except Malabar) to Burma; 1 through the deltas of the Indus, Ganges, and Brahmaputra, also Orissa; 1 to the Indus; 1 to the Coromandel coast and Southern India; 1 to Mysore and Madras; 1 to the Western coast; 2 to Burma.

[1] Includes:—(? *Cyprinus dancena*, Ham. Buch.); *Perilampus guttatus* and ? *perseus*, M'Clelland; *P. fulvescens*, Blyth; *Laubuca guttata*, Bleeker.

[2] Includes *Opsarius pholicephalus*, M'Clelland.

[3] Includes:—*Leuciscus acinaces*, Cuv. & Val., pt.; (? *Pelecus diffusus*, Jerdon).

[4] Includes:—*Opsarius albulus*, M'Clelland; *Chela Owenii*, Sykes.

[5] This may be *Leuciscus acinaces*, pt., Cuv. & Val.

[6] Includes:—*Clupea cyprinoides*, Bloch; *Chela balookee* and ? *teekaree*, Sykes; *Leuciscus dussumieri*, Cuv. & Val.; *Pelecus affinis*, Jerdon.

[7] Includes:—*Opsarius leucerus*, M'Clelland; *Leuciscus cultellus*, Cuv. & Val.; *Salmophasia oblonga*, Swainson.

Subfamily Cobitidina.

Genus Botia.

1. B. nebulosa, *Blyth*. Darjeeling.

2. B. dario[1], *Ham. Buch.* Delta of Ganges and Brahmaputra.

3. B. geto[2], *Ham. Buch.* Delta of Indus, Ganges, and Brahmaputra; also contiguous districts.

4. B. almorhæ, *Blyth*. Himalayas.

5. B. Berdmorei, *Blyth*. Delta of Irrawaddi river; also Tenasserim.

6. B. histrionica, *Blyth*. Pegu.

Species of this genus appear to thrive best on or near to hills; 1 is distributed through the deltas of the Indus, Ganges, and Brahmaputra, 1 through the deltas of the two latter rivers and contiguous districts; 2 restricted to the Himalayas; and 2 to Burma.

Genus Acanthopsis.

1. A. choirorrhynchus[3], *Bleeker*. Burma to the Malay archipelago.

Genus Somileptes.

1. S. gongota[4], *Ham. Buch.* Himalayas, Assam, and Lower Bengal.

Genus Leptocephalichthys.

1. L. guntea[5], *Ham. Buch.* Himalayas, India generally (except its southern portion and western coast).

2. L. thermalis[6], *Cuv. & Val.* Southern India, Malabar coast, and Ceylon.

[1] Includes *Diacantha flavicauda*, Swainson.

[2] Includes :—*Diacantha zebra*, Swainson; *Botia rostrata*, Günther.

[3] Includes *Prostheacanthus spectabilis*, Blyth.

[4] Includes :—*Cobitis cucura*, Ham. Buch.; *C. oculata*, M'Clelland; (? *C. amnicola*, Cuv. & Val.); *Canthophrys albescens* and *Somileptes bispinosa*, Swainson.

[5] Includes :—*Cobitis balgara*, Ham. Buch.; (? *C. phoxocheila*, M'Clelland); *Schistura aculeata*, M'Clelland; *Cobitis maya*, Sykes; *Canthophrys vittatus* and *olivaceus*, Swainson; *Misgurnus lateralis*, Günther.

[6] Includes :—*Cobitis carnaticus*, *mysorensis*, and ? *rubripinnis*, Jerdon; *Platacanthus agrensis*, Day.

3. L. BERDMOREI[1], *Blyth.* Moulmein in Burma.

The 3 species of this genus have a local distribution; 1 extending from the Himalayas as far as Southern India; 1 Southern India, Malabar, and Ceylon; and 1 Eastern Burma.

Genus ACANTHOPHTHALMUS.

1. A. PANGIA[2], *Ham. Buch.* North-east Bengal and northern portions of British and Upper Burma.

Genus APUA.

1. A. FUSCA, *Blyth.* Pegu.

Genus JERDONIA.

1. J. MACULATA, *Day.* Madras.

Genus NEMACHEILICTHYS.

1. N. RÜPPELLI, *Sykes.* Deccan.

Genus NEMACHEILUS.

1. N. EVEZARDI, *Day.* Poona in the Deccan.

2. N. PAVONACEUS[3], *M'Clelland.* Assam.

3. N. RUBIDIPINNIS[4], *Blyth.* Tenasserim.

4. N. BOTIA[5], *Ham. Buch.* From Sind, throughout India (except its southern portion and Malabar coast).

5. N. MONOCEROS, *M'Clelland.* Assam.

6. N. PULCHELLUS, *Day.* Bowany River, at base of Neilgherry hills.

7. N. SINUATUS, *Day.* Western Ghauts.

8. N. GUENTHERI, *Day.* Rivers along slopes and base of Neilgherry hills.

9. N. SEMIARMATUS, *Day.* Rivers along slopes and base of Neilgherry hills.

10. N. CORICA[6], *Ham. Buch.* Delta of Ganges and Brahmaputra.

[1] Includes *Acanthopsis micropogon*, Blyth.

[2] Includes :—*Cobitis cinnamomea*, M'Clelland; *Canthophrys rubiginosus*, Swainson.

[3] Includes *Acanthocobitis longipinnis*, Peters.

[4] Includes *Cobitis semizonata*, Blyth.

[5] Includes :—*Cobitis bilturio*, Ham. Buch.; *C. bimucronata*, *ocellata*, and *scaturigina*, M'Clelland; *C. moreh*, Sykes; *Somileptes unispina*, Swainson; *Nemacheilus aureus*, Day.

[6] Includes:—*Schistura punctata*, M'Clelland; *Acoura cinerea*, Swainson.

11. N. RUPICOLA[1], *M'Clelland.* Himalayas.

12. N. MONTANUS, *M'Clelland.* Himalayas.

13. N. STRIATUS, *Day.* Western Ghauts.

14. N. MULTIFASCIATUS[2], *Day.* Himalayas and Assam.

15. N. DENISONII[3], *Day.* Mysore, Deccan, and western Ghauts.

16. N. NOTOSTIGMA, *Bleeker.* Ceylon.

17. N. ZONALTERNANS, *Blyth.* Tenasserim provinces.

18. N. LADACENSIS, *Günther.* Tibet.

19. N. ZONATUS[4], *M'Clelland.* From the Punjab, throughout the N.W. Provinces, Bengal, Assam, and Orissa.

20. N. CINCTICAUDA, *Blyth.* Burma.

21. N. TRIANGULARIS, *Day.* Travancore hills.

22. N. SAVONA[5], *Ham. Buch.* N.W. Provinces and Bengal.

23. N. BEAVANI[6], *Günther.* From Orissa to Mysore and South India.

24. N. SPILOPTERUS, *Cuv. & Val.* Himalayas, Assam, Cochin China.

25. N. MARMORATUS[7], *Heckel.* Cashmere Lake.

26. N. STOLICZKÆ[8], *Steindachner.* Himalayas and Yarkand.

27. N. BUTANENSIS, *M'Clelland.* Boutan, in the Himalayas.

28. N. GRACILIS, *Day.* Head-waters of Indus in the Himalayas.

29. N. TURIO[9], *Ham. Buch.* Assam.

Of the 29 species of *Nemacheilus*, 8 are found in the Himalayas, one of which extends to Yarkand and another to Assam; 1 extends to the Himalayas, Assam, and Cochin China; 2 to Sind and India

[1] Perhaps includes *Cobitis microps*, Steindachner.

[2] Includes:—(? *Schistura subfusca*, M'Clelland); *Nemacheilus montanus*, Günther (not M'Clelland).

[3] Includes *Cobitis montanus*, Jerdon (not M'Clelland).

[4] Includes *Nemacheilus mugah*, Day.

[5] Includes *Acoura obscura*, Swainson.

[6] Includes *N. chryseus*, Day.

[7] Includes *Cobitis vittata*, Heckel.

[8] Includes:—*Cobitis tenuicauda*, Steindachner; *C. Griffithii*, Günther.

[9] Includes:—*Cobitis gibbosa*, M'Clelland; *C. arenata*, Val.; *Acoura argentata*, Swainson.

(except its southern portion and Malabar coast); 2 to the delta of the Ganges, one of which extends to Assam; 3 Assam; 1 Orissa and Southern India; 1 Poona; 7 Western Ghauts and rivers along their bases; 1 Ceylon; 3 Burma.

Although these fish are common enough in the waters of the plains, they are still more numerous in those of the hills.

Family Clupeidæ.

Members of this family are found in the fresh waters of India, but they can only be considered accidental residents there. Some, as the hilsa (*Clupea ilisha*), are anadromous, and only ascend the rivers to deposit their ova. Others which are more constant residents are few in number, and probably descendants of some whose progenitors have had their return to the sea cut off, and have thus become freshwater forms.

Family Notopteridæ.

Genus Notopterus.

1. N. kapirat[1], *Lacépède.* Throughout the fresh waters of the plains of India to the Malay archipelago.

2. N. chitala[2], *Ham. Buch.* Sind, Lower Bengal and Assam, Burma and Siam to the Malay archipelago.

This genus is also represented in Africa.

Family Symbranchidæ.

Three genera have representatives in India.

1. Amphipnous[3], *Müller.* India and Burma.

2. Monopterus[4], *Lacépède.* Burma, Malay archipelago, and China.

3. Symbranchus[5], *Bloch.* India to the Malay archipelago.

The following are the species belonging to this family.

[1] Includes:—*Gymnotus notopterus,* Pallas; *Clupea sinura,* Bl. Schn.; *Mystus badjee,* Sykes; *Notopterus Pallasii* and *N. bontianus,* Cuv. & Val.

[2] Includes:—*Notopterus ornatus,* Gray; *N. Buchanani,* Cuv. & Val.; *N. hypselosoma* and *N. lopis,* Bleeker.

[3] Includes *Pneumabranchus,* pt., M'Clelland.

[4] Includes:—*Fluta,* Bl. Schn.; *Ophicardia,* M'Clelland; *Apterigia,* Basilewski.

[5] Includes:—*Unibranchapertura,* Lacép.; *Pneumabranchus,* pt., and *Ophisternon,* M'Clell.; *Tetrabranchus,* Bleeker.

Genus Amphipnous.

1. A. cuchia[1], *Ham. Buch.* Punjab, throughout Bengal and Orissa, through Assam to Burma.

Genus Monopterus.

1. M. javanensis[2], *Lacép.* Burma, Malay archipelago, and China.

Genus Symbranchus.

1. S. bengalensis[3], *M'Clelland.* India to the Malay archipelago, and the Philippines.

The foregoing freshwater fishes alluded to as existing in India and Burma belong to sixteen families[4], which are distributed as follows:—

Sciænidæ, Gobiidæ, Rhynchobdellidæ, Mugilidæ, Siluridæ, Scombresocidæ, Cyprinodontidæ, Cyprinidæ, Murænidæ, all of which have representatives in the Palæarctic, African, and Oriental regions. Percidæ group *Apogonina*, Labyrinthici, Notopteridæ, which belong to the African and Oriental regions. Nandidæ group *Nandina*, Ophiocephalidæ[5], Symbranchidæ, and Chromides, all of which are restricted to the Oriental region except the last, which has a representative in Madagascar.

By giving every genus and species and adding their synonyms in the form of notes, all question as to what are included in these papers must be set at rest. Some authors may consider that I

[1] Includes:—*Ophichthys punctatus*, Swainson; *Pneumabranchus striatus*, *leprosus*, and *albinus*, M'Clelland.

[2] Includes:—*Unibranchapertura lævis*, Lacép.; *Symbranchus eurychasma*, Bleeker; *Ophicardia Phayriana*, M'Clelland; *Symbranchus grammicus*, Cantor; *Monopterus cinereus*, *xanthognathus*, *marmoratus*, and *helvolus*, Richardson; *Apterigia saccogularis*, *nigromaculata*, and *immaculata*, Basilewski.

[3] Includes:—*Symbranchus immaculatus*, Cantor; *Tetrabranchus microphthalmus*, Bleeker.

[4] Mr. W. T. Blanford, in his excellent paper on "The African Element in the Fauna of India," in the 'Ann. & Mag. of Nat. Hist.' Oct. 1876, observes of the zoological productions of India:—"I have long been convinced that many of the usual generic groups are artificial; and some are even founded upon geographical distribution—forms which inhabit Africa being placed in a different genus from those which inhabit India on account of a difference in the locality, and not of a difference in structure." However well such a remark may apply to the other branches of zoology, I do not think it is correct as regards ichthyology.

[5] I have obtained *Ophiocephalus gachua* from Beloochistan: it has likewise been taken in Afghanistan, or localities within the Palæarctic region.

have unduly multiplied some species, considering local varieties as more appropriate; by referring to those enumerated it will be easy to erase those objected to. Others, I know, think that some which I have placed as synonyms should be given as species. Anyhow, by following out every form as I have done, I have tried to obviate one of Mr. Blanford's objections, that "with only the facts procurable from museum catalogues and other published works, I know from experience that it is impossible to ascertain correctly the details of distribution; the numerous errors committed by the older naturalists, by whom the term India was used in the very loosest and vaguest sense, have but rarely been eliminated; and it is constantly the practice in monographs and catalogues to quote species and genera as found in two localities—the old and erroneous one, and the real locality subsequently discovered" (Ann. & Mag. Nat. Hist. 1876, xviii. p. 278).

The fishes I have enumerated belong to 87 *genera*, thus distributed:—

No. of genera in India.	Also in the Malay archipelago and Africa.	In Malay archipelago.	In Africa.
19 Acanthopterygii	4[1]	10	0
26 Siluridæ	1[2]	10	0
1 Scombresocidæ	1[3]	0	0
2 Cyprinodontidæ	1	0	1[4]
35 Cyprinidæ	4[5]	10[6]	1[3]
1 Notopteridæ	1	0	0
3 Symbranchidæ	0	2	0
87	12	32	2

It appears that out of 87[7] genera, 2 only are restricted to Africa (not being Malayan), both being likewise Palæarctic; 32 extend to the islands of the Malay archipelago; 12 are common to both the African and Malayan regions, out of which 6 are likewise Palæarctic.

[1] 2 are also Palæarctic; the other two, *Periophthalmus* and *Eleotris*, have marine representatives also.

[2] and [3] Also Palæarctic.

[4] *Cyprinodon* also Palæarctic; *Haplochilus* not so.

[5] *Barilius* has been taken at Candahar; *Rasbora* is not known to be Palæarctic, the remaining two are.

[6] Out of these 10 genera, 3 are Burmese, not belonging to the Hindustan subregion.

[7] Genus *Etroplus* will be considered separately.

If we tabulate the 369 Indian freshwater *species* in the same manner, they will be found thus distributed:—

No. of species in India.	Also in the Malay archipelago and Africa.	In Malay archipelago.	In Africa.
47 Acanthopterygii	2	9[2]	0
85 Siluridæ	0	6	0
1 Scombresocidæ	0	0	0
5 Cyprinodontidæ	0	1	1[4]
226 Cyprinidæ	0[1]	7[3]	1[5]
2 Notopteridæ	0	2	0
3 Symbranchidæ	0	2	0
369	2	27	2

Leaving out the question of the original home of the first parents of these fishes, we may inquire, *what element is now most apparent amongst the Indian freshwater fishes, the African or Malayan?* A single glance at the Tables will show that the Malayan element is most developed. In short, we are unable to ascertain one single *genus* which is solely African and Indian, as all the African forms which extend to India are either likewise present in the Palæarctic region, or else in the Malay archipelago, or in both.

If we turn to the distribution of the species, we obtain the same results. Out of 369 Indian or Burmese forms, 2 are likewise African (not Malayan), but they are also Palæarctic; 27 are common to India (including Burma) and the Malay archipelago; 2 to both Africa, India, and the Malay archipelago.

How has the African element entered India proper[6]? I exclude

[1] *Discognathus* is also Palæarctic.

[2] *Pristolepis fasciatus* is Burmese, and not found in the Hindustan subregion.

[3] Out of these 7 species, 5 are found in Burma, but not in the Hindustan subregion.

[4] and [5] Both Palæarctic forms.

[6] Mr. Blanford considers there is evidence that in Northern and Central India the fauna in the later Tertiary times was more allied to that now existing in Africa than it is now—that this is shown by the presence of *Hippopotamus, Camelopardalis, Loxodon*, and a number of antilopine forms in the Pliocene fossil fauna of the Sevaliks &c.,—and states his belief that the Vertebrata had been in connexion with Africa:—*first*, forms common to the Oriental and Ethiopian regions, the bulk of the present Indian fauna; *secondly*, forms common to the Ethiopian region and India, but not extending to the eastward of the Bay of Bengal, nor represented in S.W. Asia now lying in the direct line between India and Africa; *thirdly*, species with Ethiopian affinities, which may have wandered into India from Arabia and Baluchistan.

from this consideration whether at some earlier period of the world's history a migration of fishes occurred from the north, and as they travelled south some found their way into Africa, others into India; while as their distance from their base increased, and due to climatic and other disturbing causes, they became modified as we now find them. Although all the genera of fishes which I have alluded to as common to Africa and India are freshwater, some are commonly residents within tidal influence. I will therefore subdivide the 14 genera into (1) strictly freshwater forms, and (2) those which contain some representatives which reside in the sea.

	Genera.	Ethiopian subregion.	Mediterraneo-Persic subregion.
Strictly freshwater.	Mastacembelus	W. Africa.	Present.
	Gobius	All.	,,
	Clarias	All.	,,
	Discognathus	E. Africa.	,,
	Labeo	All.	,,
	Barbus	All.	,,
	Barilius	E. Africa.	,,
	Rasbora	E. Africa.	Absent.
	Notopterus	W. Africa[1].	,,
Some marine forms.	Periophthalmus	E. & W. & S. Africa.	,,
	Eleotris		,,
	Belone	All.	Present.
	Cyprinodon	E.	,,
	Haplochilus	E.	Absent.

It would thus appear that the irruption of the majority of the freshwater forms common to Africa and India must have been by way of the Mediterraneo-Persic subregion.

We have now to consider what freshwater fishes are found in the various subregions of the *Oriental region*, and which are peculiar to each. I propose taking Mr. Wallace's subdivisions, having the deltas of the Ganges, Indus, and the Brahmaputra as the boundaries of the *Hindustan subregion* on the N.W., N., and N.E., while on the S.W. it extends to the Ceylonese subregion. The *Ceylonese subregion* commences on the western coast below Goa, and includes Canara and Malabar with the western Ghauts to Ceylon; passing along the Neilgherries, its fish fauna in Mysore joins with that of the Hindustan subregion; while in the Carnatic it extends in like manner as high as the river Kistna. Out

[1] This Malayan element in West Africa corresponds with what has been observed in mammals and birds.

of 73[1] genera present in the Hindustan and Ceylonese subregions, we find them thus distributed[2] :—

73 genera, where distributed.	Acanthopterygii.	Siluridæ.	Scombresocidæ.	Cyprinodontidæ.	Cyprinidæ.	Notopteridæ.	Symbranchidæ.
Hindustan, Ceylon, Burmah to Malay archipelago	9	8	1	1	10	1	3
Hindustan and Ceylon subregions	1	0	0	0	1	0	0
" " to Burma or beyond	1	1	0	0	6	0	0
Hindustan subregion	0	4	0	1	2	0	0
" " to Burma or beyond	4	7	0	0	5	0	0
Ceylonese subregion	1	0	0	0	1	0	0
" " to Burma or beyond	4	1	0	0	0	0	0

Out of the foregoing 73 genera of freshwater fishes which are found in the Hindustan and Ceylonese subregions, no less than 62 extend to Burma or the Malay archipelago, or to both; whereas only 15 are common to the Palæarctic region. Thus we not only observe the comparatively small amount of the Ethiopian element in the Indian fish-fauna, but also find that (excluding the Himalayan forms) the ichthyology of India and Ceylon is far less Palæarctic than it is Malayan.

The Oriental genera (excluding the Himalayan) which are distributed more or less through its subregions of Hindustan, Ceylon, Burma and Siam, and the Malay archipelago, but possess neither Ethiopian nor Palæarctic representatives, are as follows:— 1. *Nandus*, 2. *Pristolepis*, 3. *Sicydium*, 4. *Ophiocephalus*, 5. *Channa*, 6. *Anabas*, 7. *Polyacanthus*, 8. *Osphromenus*, 9. *Liocassis*, 10. *Pangasius*, 11. *Pseudeutropius*, 12. *Callichrous*, 13. *Wallago*, 14. *Chaca*, 15. *Bagarius*, 16. *Glyptosternum*, 17. *Homaloptera*, 18. *Cirrhina*,

[1] The Burmese and Himalayan genera which are not common to Hindustan are omitted.

[2] It is to be regretted that, with the exception of some portions of the Himalayas and the western Ghauts of India, the hill-ranges scattered over Hindustan have not had their fishes sufficiently collected. H. D. Thomas, Esq., of the Madras Civil Service, has lately sent me a collection made on the Sheverry hills in Madras; and they are identical with those of the neighbouring plains.

19. *Thynnichthys*, 20. *Chela*, 21. *Botia*, 22. *Acanthopsis*, 23. *Lepidocephalichthys*, 24. *Amphipnous*, 25. *Symbranchus*, and 26. *Monopterus*.

Among those genera which are restricted to the *Hindustan subregion* we have :—1. *Ailia*, 2. *Ailichthys*, 3. *Sisor*, 4. *Nangra*, 5. *Psilorhynchus*, and 6. *Somileptes*, all being found in the deltas of the rivers Indus, Ganges, and Bramaputra, or their affluents. Restricted to the *Ceylonese subregion* we have 1. *Etroplus*, 2. *Jerdonia*. The following are found in the *Ceylonese and Hindustan subregions, also in Burma* :—1. *Badis*, 2. *Saccobranchus*, 3. *Rohtee*, 4. *Amblypharyngodon*, 5. *Nuria*, 6. *Danio*, 7. *Perilampus*, 8. *Semiplotus*, and 9. *Amphipnous*. Restricted to *Hindustan and Burma*:—1. *Trichogaster*, 2. *Erethistes*, 3. *Rita*, 4. *Silundia*, 5. *Eutropiichthys*, 6. *Gagata*, 7. *Catla*, 8. *Aspidoparia*, and 9. *Acanthophthalmus*.

Having thus briefly examined what the Indian freshwater fish-fauna is as a whole, we next come to the consideration of *what is the Fish-fauna of Ceylon*? Here a great difficulty exists, as the fishes of that island still remain to be thoroughly worked out. Bleeker's 'Cobitoides et de Cyprinoides de Ceylan' unfortunately does not enumerate the localities whence his examples were obtained; consequently one is ignorant as to whether they came from the northern or southern districts, or from both. And this question is important when examining into the zoology of that island, the southern portion consisting of hill-tracts which Mr. Blanford classes with Malabar and the "low country on the west coast of India from Cape Comorin to a little north of Bombay, and a range of hills near the same coast as far north probably as the Tapti river." The northern portion of Ceylon, he considers, belongs to the Indian province or subregion.

Some materials, however, exist for investigating this question, as we know of 41 species of freshwater fishes belonging to 29 genera inhabiting Ceylon. The *genera* consist of 9 Acanthopterygians, 6 Siluroids, 1 Scombresocid, 1 Cyprinodont, and 12 Cyprinoids, with one exception, all having representatives in Malabar, the single exception being the genus *Channa*, very closely allied to the ubiquitous Indian genus *Ophiocephalus*, from which it is separated because it is deficient of ventral fins.

The 41 *species* consist of :—13 Acanthopterygians, 9 of which extend through India and Malabar; 1 to Southern India and Malabar; 1 to Java and China; whilst 1 is restricted to Ceylon. 7 Siluroids, 4 of which are distributed through India and Malabar;

1 to South India and Malabar; 1 to Java; and 1 restricted to Ceylon. 1 Scombresocid, common to India and beyond. 1 Cyprinodont, found also in Malabar. 19 Cyprinoids, 3 of which are distributed through India and Malabar, 1 extending to Africa; 6 to South India, 5 of which are also found in Malabar; 1 to India, excluding Malabar; 2 to Malabar; while 7 are restricted to Ceylon.

In short, the freshwater fish-fauna of Ceylon would show a very slight connexion with Africa, and that only through the same genera being distributed throughout India and Malabar; but certainly there exists a Malayan[1] element, to which I shall refer further on.

The Malabar fish-fauna is intimately related to that of Ceylon and (but to a decreased extent) with that of the southern portion of the Coromandel coast, as some species extend their range as far as the Kistna. The following Table will show the relationship of the Ceylonese freshwater fish-fauna to that of the remainder of the region on the continent of India, also how it agrees with the Hindustan subregion or elsewhere.

Family and Genus[2].	Subregions.			Range beyond region.
	Ceylonese.			
	Ceylon.	Malabar and mainland.	Hindustan.	
ACANTHOPTERYGII.				
1. *Ambassis*	1	1	1	Africa; Burma, Siam, Malay archipelago.
2. Badis	0	1	1	Burma.
3. Nandus	0	1	1	Burma, Siam, Malay archipelago.
4. Pristolepis	0	1	0	Burma, Siam, Malay archipelago.
5. *Gobius*	1	1	1	Cosmopolitan.
6. Sycidium	0	1	0	Burma, Malay archipelago, and beyond.
Carried forward	2	6	4	

[1] Wallace remarks of Ceylon that although it "generally agrees in its productions with the southern part of India, yet it has several birds which are allied to Malayan and not to Indian groups, and a fine butterfly of the genus *Hestia*, as well as several genera of beetles, which are purely Malayan."

[2] Those genera which have marine as well as freshwater representatives are printed in italics.

Family and Genus.	Subregions.			Range beyond region.
	Ceylonese.		Hindustan.	
	Ceylon.	Malabar and mainland.		
Brought forward ...	2	6	4	
ACANTHOPTERYGII (*continued*).				
7. *Eleotris*	1	1	1	Africa; Burma, Siam, and Malay archipelago.
8. Mastacembelus ...	1	1	1	Mediterraneo-Persic region, West Africa, Burma, to Malay archipelago.
9. Ophiocephalus ...	1	1	1	Burma, Siam, to Malay archipelago and beyond.
10. Channa	1	0	0	China.
11. Anabas	1	1	1	Burma, Siam, Malay archipelago, and beyond.
12. Polyacanthus	1	1	0	Malay archipelago.
13. Etroplus	1	1	0	
SILURIDÆ.				
14. Macrones	1	1	1	Burma, Siam, Malay archipelago.
15. Pseudeutropius ...	1	1	1	Burma, Siam, Malay archipelago.
16. Callichrous	1	1	1	Burma, Siam, Malay archipelago.
17. Wallago	1	1	1	Burma, Siam, Malay archipelago.
18. Silurus	0	1	0	Himalayas, Burma, Siam, Malay archipelago, China; Palæarctic region.
19. Clarias	1	1	1	Africa, Mediterraneo-Persic region, Burma, Siam, Malay archipelago, &c.
20. Saccobranchus ...	1	1	1	Burma, Siam, Cochin China.
21. Bagarius	0	1	1	Burma, Siam, to the Malay archipelago.
22. Glyptosternum ...	0	1	1	Malay archipelago.
SCOMBRESOCIDÆ.				
23. *Belone*	1	1	1	Almost cosmopolitan.
Carried forward	16	22	17	

Family and Genus.	Subregions.			Range beyond region.
	Ceylonese.		Hindustan.	
	Ceylon.	Malabar and mainland.		
Brought forward ...	16	22	17	
CYPRINODONTIDÆ.				
24. Haplochilus	1	1	1	Tropical Africa, Burma, and the Malay archipelago.
CYPRINIDÆ.				
25. Homaloptera	0	1	0	Himalayas and Malay archipelago.
26. Discognathus	1	1	1	Africa, Mediterraneo-Persic region, Himalayas, Burma.
27. Cirrhina	1	1	1	Burma to the Malay archipelago, &c.
28. Scaphiodon.........	0	1	0	Mediterraneo-Persic region and Sind hills.
29. Amblypharyngodon.	1	1	1	Burma.
30. Barbus	1	1	1	The Old World.
31. Nuria	1	1	1	Burma and the Nicobars.
32. Rasbora	1	1	1	Africa, Burma, to the Malay archipelago.
33. Rohtee...............	0	1	1	Burma.
34. Barilius	1	1	1	East Africa, Burma, to the Malay archipelago.
35. Danio	1	1	1	Burma.
36. Perilampus.........	1	1	1	Burma.
37. Chela	1	1	1	Burma to the Malay archipelago.
38. Lepidocephalichthys.	1	1	1	Burma to the Malay archipelago.
39. Jerdonia	0	1	0	
40. Nemacheilus	1	1	1	Burma to the Malay archipelago.
NOTOPTERIDÆ.				
41. Notopterus	0	1	1	Burma to the Malay archipelago.
SYMBRANCHIDÆ.				
42. Symbranchus	0	1	1	Burma to the Malay archipelago and beyond.
Total	29	41	33	

We can deduce the following results as to the distribution of the 29 genera present *in the island of Ceylon.*

Present on the mainland of the Ceylonese subregion.	Present in Hindustan.	Present elsewhere.
28	26	1 China; 1 Madagascar; but also mainland.

The Malabar fish-fauna is intimately related to that of Ceylon, and (but to a diminishing extent) with the southern portion of the Coromandel coast, as some species extend their range as far as the Kistna. Amongst the Cyprinidæ, 16 *genera*[1] are represented in Malabar, 12 of which are likewise found in Ceylon: of the remaining 4, 1 is common to the western Ghauts and the Himalayas, 1 to Western Asia and Sind; while of the other 2, one is distributed through India, the other is local at Madras. Ceylon possesses no genus of Carps unrepresented in Malabar.

Of *species*, 60 are found from Canara down to the western Ghauts (including the Neilgherry hills and rivers at their bases) and Ceylon; 40 are found in Canara or Malabar (2 of which are common to the Himalayas, and 5 to the plains of India); 7 are found in Malabar and Ceylon; 7 restricted to Ceylon; 1 to India and Ceylon.

Amongst the Acanthopterygians, 11 *genera* are found in Malabar and Ceylon: 2 of these are restricted to Malabar; 2 are common to India and Malabar; 6 to India, Malabar, and Ceylon; 1 is only found in Ceylon. Of *species*, 27 are found in Malabar and Ceylon: 14 are Malabar forms, 7 of which are found in the plains of India; 9 are common to India, Malabar, and Ceylon; 1 to Malabar and Siam; 3 to Ceylon, one of which extends to Java.

I have now to refer to a certain peculiar distribution of fishes, already remarked upon, but respecting which a more detailed examination is necessary.

Genus *Pristolepis* is found along the western Ghauts of India, is absent from the Hindustan subregion, but reappears in Burma, whence it is distributed to the islands of the Malay archipelago. *Ophiocephalus micropeltes* is found from Canara to Cochin, is absent from Hindustan, but reappears in Siam.

[1] This must not be understood to mean that these genera are absent from the waters of the plains of India.

O. gachua is found at the Andaman Islands. Genus *Channa* is found in Ceylon and China, but absent from intermediate localities. *Polyacanthus signatus* has only been taken in Ceylon and Java. Genus *Etroplus* through the Ceylonese subregion, and an allied genus in Madagascar. Genus *Silurus*, Himalayas to Akyab, Tenasserim, Cochin China, the Malay archipelago and beyond; also Eastern Europe and Turkestan, and along the Malabar Ghauts; but is not found in the Hindustan subregion. *Exostoma* along the Himalayas to Assam, Pegu, Tenasserim, and the confines of China. *Haplochilus panchax* from the Hindustan subregion, through Burma and Siam to the islands of the Malay archipelago, and is also common at the Andaman Islands. *Scaphiodon* from Western Asia to the Sind and the Punjab, and along the western Ghauts, but is otherwise absent from India. *Nuria danrica* extends from the Ceylonese and Hindustan subregions to Burma and the Nicobars; but is absent from the islands of the Malay archipelago. *Homaloptera Brucei* and *H. maculata* are common to the Himalayas and the western Ghauts of India, but are absent from the Hindustan subregion.

The preceding and other somewhat similar instances offer a wide field for conjecture as to how these fishes came in such localities, and by what means they have spread to more distant districts; but before offering any remarks on the subject, it will be necessary to digress a little, and refer to the opinions of others who have written on this question.

Geologists have pointed out that the plains of Hindustan are Tertiary with a few isolated patches of Secondary rocks, and the peninsula in the later Tertiary epoch was an island, an arm of the sea existing along the present deltas of the Ganges and the Indus. Ceylon and South India consist (at least on the western Ghauts) mainly of granitic and old metamorphic rocks; and they probably formed during a portion of the Tertiary period a large continent, the zoology of which had a close affinity to that of the Malayan region.

Dr. Stoliczka observed that "it does not appear improbable that the fauna of India was at some remote period chiefly or altogether Malayan, and that it had been more or less destroyed in those parts which were affected by the enormous volcanic eruptions, characterized as the Trappean formation of Central and N.W. India. It must have been somewhere about that time when a communication was established between India and Africa,

and when African forms were enabled to travel eastwards and attain a firm hold in India. The immigration from the west must have been considerable; for it seems to have greatly checked the further development of the Malayan fauna, which remained preserved only on the more elevated hills, chiefly those consisting of gneissose and metamorphic rocks" (Proc. As. Soc. 1871, p. 84).

In short, many zoologists consider that the Indian fauna was formerly very similar to the Malayan; that something occurred which acted injuriously on that fauna; while a communication occurring with Africa, and perhaps due to the Indian climate becoming more tropical, a development of African forms occurred, but that this commingling did not take place on the more elevated regions; that afterwards there was a large irruption of Malayan forms due to a connexion being formed between Burma and Eastern Bengal, and that they overran the Hindustan subregion.

The distribution of the freshwater fishes in these regions ought to give us some facts which support or refute these opinions; for although marine fishes can ascend into fresh-water, and should their retreat to the sea be cut off, they are able to make it their home, it is not so with true freshwater forms, which never breed in the sea, and cannot exist in it for any length of time. Thus the freshwater forms are unable to pass from the mainland to islands[1]; they must have a freshwater channel up which they can proceed; but for this to exist, a land-continuity becomes necessary. Land connexion alone between two continents may not always be sufficient; as even if such were present, it does not necessarily follow that freshwater would be also there. Again, a mountain-chain may extend across the isthmus over which freshwater fishes would not be able to pass.

It has been advanced that freshwater fishes have two modes of dispersal:—(1) carried by external agency out of one river-system to another, or from the mainland to islands; (2) by river-sytems due to some cause commingling and permitting the fish to migrate.

Under the head of external agency, the action of hurricanes and whirlwinds have been adduced, when with the downpour of

[1] Wallace observes of *Amphibia*:—"Salt water is fatal to them as well as to their eggs; and deserts and oceans would probably form the most effectual barriers to their dispersal; whereas both snakes and lizards abound in deserts, and have some means of occasionally passing the ocean which frogs and salamanders do not seem to possess."

water fishes are said to have descended, it is assumed in a living state; but of the instances I have had unequivocal evidence of, they were invariably dead, sometimes putrid. Proof of their descending alive is yet wanting. Then it has been stated, on the authority of Gmelin, that fish-eggs may be carried by aquatic birds. It appears hardly credible that fish-eggs could be swallowed by birds and subsequently extruded *per anum* with their vitality intact. If the fish were ovi-viviparous, the mothers (inside whom were fertilized eggs) might be swallowed, and thus the eggs might (?) be extruded with the vitality unimpaired. But there are no Indian freshwater fishes which are ovi-viviparous; and the aquatic bird which swallowed the unfertilized fish-eggs would hardly assist in producing fishes in distant localities. That some birds might gorge themselves with fish-eggs, and having flown some distance, might disgorge some, is not improbable; and in such a manner fishes might be distributed. In fact, in India we see some marine forms of Siluroids in which the males carry about the eggs in their mouths until the young are hatched. Water-beetles are likewise believed to occasionally convey fertilized fish-eggs from one piece of water to another, and sometimes without destroying their vitality.

Respecting river-systems, by commingling (due to changes in level, or from other causes), enabling fish to migrate, such appears to be very likely. One might take as an example how some of the Himalayan streams go to the Indus and western coast of India, and others descend to the Ganges and pass to the Bay of Bengal. Here a communication by their lateral branches might occur during some period of flood.

But I have shown that some fishes of the western coast of India and Ceylon have a very peculiar distribution; present along the mountain-summits or some distance up their sides, they are absent from the plains, but reappear in the Himalayas, in Burma, Siam, the Malay archipelago, or China.

The geographical distribution of the amphibious Oriental family of Ophiocephalidæ is well worthy of an attentive investigation. Species extend through vast districts. Thus *O. striatus* is found throughout the fresh waters of the plains of India and Ceylon, Assam, Burma, Siam, and in most of the islands of the Malay archipelago. This would be one reason for believing either that these freshwater fishes at a former period could inhabit the sea and thus extend from island to island, or else that land once joined

these islands together and to the mainland, while over this land were streams or ponds of fresh water along which these fishes went. *O. gachua* is first met with at Guadur, also on the hills of Beluchistan and Afghanistan; it extends through the Indian and Ceylon subregions, Assam, and Burma; while, as I have formerly remarked, it is common in the streams at the Andaman Islands. I can only account for their presence in such a spot by the same theory of a former land-connexion with the mainland; the distance is too far for any accidental cause to have occasioned its presence there.

O. micropeltes is present in the rivers of Canara and Malabar, absent from the plains of India and Burma, reappearing in Siam; and is distributed through the fresh waters of the islands of the Malay archipelago. The allied genus *Channa* is also found in Ceylon, but disappears between that island and China. The percoid genus *Pristolepis* exists at the base of the Malabar hills, but is not found elsewhere in India, reappearing in Burma. The amphibious *Polyacanthus signatus* is only found in Ceylon and Java.

The delicate little *Haplochilus panchax* is distributed in the fresh waters of the Andaman Islands, and is likewise found through the Ceylonese and Hindustan subregions, also in Burma and the islands of the Malay archipelago.

But the Nicobars give us another freshwater fish which is absent from the islands of the Malay archipelago, but present on the mainland of India, Burma, and Siam, whence it has probably spread; it is the little *Nuria danrica*, of which Mr. Ball brought several examples from the Nicobars.

Amongst the Siluridæ we find somewhat the same distribution may occur. *Clarias magur* is found throughout India, Burma, and the Malay archipelago, *C. Teysmanni* in Ceylon and Java, and *C. Dussumieri* along the coasts of India and the islands of the Malay archipelago, these last two, so far as is known, being absent from the intervening districts. The Cyprinoid *Thynnichthys* is also a resident only in the Deccan, Kistna, and Godavery rivers in India, reappearing in the islands of the Malay archipelago.

These examples of distribution are not peculiar to fishes, but are seen in other divisions of the animal kingdom, and would seem to point out that there must at a former period have existed a land communication between Malabar and Ceylon and the Malay

peninsula, and which may have embraced the Andamans and Nicobars.

Mr. Kurz (Journ. As. Soc. 1876, p. 105) observes that "the Nicobars form a link in the chain of islands that stretches up from Sumatra to the Arracan Yomahs (mountains), and they are in all probability the remnants of a mountain-range that connected Sumatra (and more especially the Nias Islands, where the same sandstone prevails as that of the Andamans and Arracan) and Arracan at a time when the sea covered the vast alluvial plains of the Ganges and the Indus, thus rendering Hindustan an island subsequent to its probable connexion with Africa."

Were the chain of mountains carried from about the Nicobars to the west and joined to Ceylon, we should thus have the means of communication between the Malay peninsula and the Ceylon region complete: we could in this manner understand how freshwater fishes might be absent from the subregion of Hindustan, but present on either side, as Ceylon and Burma. Perhaps, as has been advanced, the Bay of Bengal was a portion of a large continent now submerged, and it was by that route that the Ceylonese subregion received its Oriental forms of animal life at a time when the plains of Hindustan were submerged.

That this region did not extend to Madagascar or the Mauritius would also appear to be demonstrated by the freshwater fishes; for we do not find (unless they have been introduced) Rhynchobdellidæ, Ophiocephalidæ, nor the genera *Polyacanthus*, *Osphromenus*, *Trichogaster*, nor any of the Indian genera of the Siluridæ, Cyprinodontidæ, Cyprinidæ, or Symbranchidæ[1].

But in the higher elevations of the western Ghauts I have observed that forms occur similar to those of the Himalayas, and also having representatives on the Malay peninsula and in the Malay archipelago; I have also remarked upon the genus *Scaphiodon* extending from the rivers of Syria, Palestine, and Asia Minor to Sind, where they have representatives in the hills, and also to the Salt range of the Punjaub. Passing along the western Ghauts, we again come upon the same genus, which extends to the most southern extremity of the Neilgherries[2]. In a similar

[1] See 'Poissons de Madagascar,' Bleeker, 1874.

[2] I may also suggest an alternative route. *Homaloptera Brucei* and *H. maculata* are both found in the western Ghauts and also on the Himalayas. The genus exists in Java and Sumatra; we can also trace it up the Tenasserim coast, but it is absent from the Hindustan subregion. It would seem to have spread

manner I have taken the Siluroid genus *Euglyptosternum* from the rivers of the hills of N.E. Assam, from the upper portion of the Jumna at the foot of the Himalayas, and it likewise has been captured in Syria. *Barilius*, likewise found in East Africa, is distributed to both the Hindustan and Ceylonese subregions, extending into the Himalayas, and also distributed along the western Ghauts to Ceylon. These facts, if they prove any thing, would serve to show that at a former period a communication must have extended up the western coast of India to Sind; and as we do not find African types represented on the western Ghauts, we may infer that such occurred prior to the communication which took place between Africa and India. If, however, one genus of Carps could pass this way, so could another; and by this route the means of extension to the Himalayas would have been open; while by Ceylon and the Andamans fishes might also have extended to the Malay peninsula or the islands of the Malay archipelago.

I will but briefly remark upon the freshwater fishes of the Himalayan region, as I have elsewhere ("Fishes of Yarkand," P. Z. S. 1876, p. 781) followed out their distribution. We find two great classes, the Tartarian fauna from the Palæarctic region above the Himalayan descending to where it meets the Hindustan forms. It must not be forgotten in working out the details of these regions, that vast valleys having a tropical temperature exist in the Himalayas; and here some Indian forms have found congenial homes.

The *Schizothoracinæ*, or hill Barbels, are entirely distinct from any low-country forms, consisting of *Carps more or less covered with minute scales or destitute of any; a membranous sac or slit exists anterior to the anal fin, and is laterally bounded by a row of vertically-placed scales arranged like eave-tiles, and which are continued along the base of the anal fin.* The genus *Oreinus* is that most frequently observed by European visitors to India, as it is found along the sub-Himalayan range: it is possessed of a transverse inferior mouth, and a sucker behind the lower jaw, demonstrating its necessity for some mechanical apparatus to enable it to withstand the force of the hill-torrents. As we ascend to the higher and less precipitous regions we find the gape of the

from the Malay archipelago; but it is remarkable that the same species should only be found in two such widely separated localities as the Himalayas and the Ceylonese subregion of India.

mouth, if transverse, is anterior in the various genera; but the head is most commonly compressed, and the dorsal fin armed with a strong, serrated bony ray.

Having thus briefly shown the distribution of the Indian freshwater fishes, and traced out the countries from which they have been derived, we come to the question, *What are the most typical families having representatives in India?*

Those most extensively distributed are the Ophiocephalidæ and Symbranchidæ, to which I have already alluded as strictly Oriental forms possessing an amphibious respiration: next we have the Labyrinthici, also Oriental, but with some African representatives which, however, do not extend to India; the Oriental genus *Anabas* extends from Assam to the eastwards; *Osphromenus* from N.E. Bengal and Assam, also to the east; whilst some have a more local range, as *Trichogaster*, from the Hindustan subregion to Burma.

Doubtless the Siluridæ and Cyprinidæ are the forms most prevalent in the Indian fresh waters, the former being represented by 26, the latter by 35 genera. I propose first to investigate the Cyprinidæ, as they appear to be of a more northern (if not Palæarctic) origin than the scaleless Siluroids. Amongst the Cyprinidæ the first thing that deserves attention is the absence of additional means of respiration to the gills, as we see in the Acanthopterygians (as in Ophiocephalidæ and amongst the Labyrinthici), an addenda which is likewise seen amongst the Siluroids in the genera *Clarias* and *Saccobranchus*, and in the Symbranchidæ in the genus *Amphipnous*.

Seeing that out of these four large divisions of Indian freshwater fishes, the Cyprinidæ is the single one not possessing any species favoured with an amphibious form of respiration, we come to the consideration of what are the most typical genera of Indian Carps. We know of 226 species of Carps in India, 70 of which, or nearly one third, belong to the genus *Barbus*, a genus which has very close affinities with several others. If the mouth were a little more transverse, it would lead us to the *Cirrhina*[1], possessing 5

[1] *Cirrhina latia* takes on various modifications in accordance with the localities it inhabits. In hill-streams it is seen as if it attached itself by the lower surface of its head to stones, as we find occurs in *Discognathus*, and the rudiment of a pad may be observed behind the lower lip. The passage of this form into *Discognathus*, having about the same number of rays and scales, would not appear to be very difficult. There is likewise another curious structural change which

species, while *Labeo*, with its 25 species, is simply a *Cirrhina* with more developed lips and a more extended dorsal fin; and the Burman forms of *Osteochilus* and *Dangila* are not very distantly removed from *Cirrhina* and *Labeo*.

Of the genus *Barbus* we have 3 subgenera :—(1) *Barbodes*, with four barbels, the species of which, if soberly coloured, attain to a large size, as the Mahseer to 90 lb., or even upwards of 100 lb., in weight; whereas those which are found richly coloured in clear and rapid mountain-streams are usually small: a strong dorsal spine (unless serrated) is mostly a sign that the species exists in the vicinity of high mountains. (2) Subgenus *Capoëta*, with two barbels, never attain the size reached by many of those with four barbels; some, especially when residents of hill-streams, are vividly coloured. (3) Subgenus *Puntius*, destitute of barbels, are usually of a small size.

If we briefly examine into the distribution of these three subgenera of the genus *Barbus*, we observe that the forms which exist in the European subregion are only those possessing four barbels; that they are distributed as far as the other divisions of the genus, but diminish in size the nearer they are to the tropics, provided they are solely residents of the waters of the plains. The subgenus *Capoëta* has not been recorded from Europe, but has been taken in Africa and also in Persia; still its numbers are small until we arrive at the Oriental region, throughout which it is distributed. The subgenus *Puntius* appears to be confined to Southern Africa and the Oriental region.

The foregoing seems to show that the larger forms, all of which are *Barbodes*, are probably descendants from Palæarctic progenitors. And this view is still further confirmed if we investigate *where these fishes breed*. If the hot plains of India in which they abound were the home of their ancestral forms from immemorial

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occurs not only in old examples of *Discognathus*, but in other Carps having Palæarctic representatives. I allude to a deep transverse fissure (generally accompanied with numerous large glands in its vicinity) which in some adults extends across the snout (see 'Fishes of India,' pls. 122 and 123), in others only a trace of such is present. We see the same modification occur in large examples of *Labeo* or *Cirrhina* in hilly regions and Assam, also, but to a less extent, in some species of *Barbus*, as *B. Thomassi* from the western Ghauts and *B. spilophilos* in Assam; while the only other true Carp which has *Palæarctic* representatives (excluding *Scaphiodon*) is the *Barilius*, and in hill examples of *B. tileo* this fissure is more or less well marked.

time, we should expect to see them breeding there; but we find that Barbels in India breed either in the waters of the plains or in those of hilly regions, whilst it is an invariable rule that the larger forms choose the latter place. Thus we see the Mahseer and its allies residents of rivers which take their origins in mountains, that during the cold months of the year, when the mountain-streams are at their minimum size, these fishes descend to the waters of the plains, but reascend the hill-waters with the first burst of the monsoon in order to deposit their ova in cooler localities. Although this is most easily observed on the Himalayas, I have likewise found the Mahseer in Sind, and that it ascends the Beloochistan hills to breed; that the same phenomenon occurs in Malabar, where the rivers descend from the western Ghauts; and I have likewise been fortunate enough to be a witness to the fact that the larger species of Barbel (*Barbodes*) in Southern India ascend the Neilgherry streams for the same purpose.

Some species of *Barbodes* of a moderate size breed in the waters of the plains of India; but these have generally a serrated bony ray to the dorsal fin. As a rule, all Barbels breeding in the plains are of a moderate or small size; whilst of the subgenus destitute of any barbels (*Puntius*) all are small, some minute, whilst none normally breed in hill-waters. This leads me to believe that *Puntius* is a degenerate *Barbodes*, due perhaps to constant residence in the plain; that such deterioration is shown in their diminutive size and want of barbels.

If such is the case, we ought perhaps to be able to show species in which this modification is even now going on; and such I believe I have found in Southern India. *Barbus mahicola*, Cuv. & Val., has two barbels, but is otherwise similar to *B. filamentosus*, Cuv. & Val., which possesses none. Should a number of examples be examined, it is seen that these appendages in some are very minute, being, as a rule, smallest in specimens obtained furthest from the hills. In South Canara, the Wynaad, and base of the Neilgherries, where the finest examples are met with, *B. mahicola* abounds; towards Cochin and up the Coromandel coast as far as Madras the barbels, when present, are small, and the *B. filamentosus* is the common type.

I may also here record a curious change which has occurred in one species of *Barbus*, the *B. conchonius*, H. B., which has been transported, within the memory of man, from the plains into the *Nainee-tal* lake on the Himalayas. It is evidently losing the ser-

rations from its dorsal spine; and in time, if this continues, it will become more like *B. terio*, H. B., than the typical form.

On the other hand, some Carps would appear to be more derived from the east, as:—*Chela*, from the Malay archipelago to the Hindustan and Ceylonese subregions; *Semiplotus*, from Burma to Assam; *Catla*, also from Siam and Burma to the Hindustan (but not the Ceylonese) subregions; *Amblypharyngodon*, *Danio*, *Perilampus*, *Nuria*, and *Rohtee*, from Burma to India generally.

If we now turn to the Siluridæ or scaleless fishes, we find them represented by 26 genera composed of 85 species, demonstrating how inferior in numbers they are to the Carps. Some of these genera, as *Clarias* and *Saccobranchus*, have, as I formerly observed ("On Amphibious and Migratory Fishes of Asia," Journ. Linn. Soc. Zool. vol. xiii. p. 198 *et seq.*), respiratory organs having a lung-like function, and which are distinct from the gills; and as all fishes having these accessory breathing-organs are restricted to tropical regions, we may assume that *Clarias* and *Saccobranchus* are tropical fishes.

I have already (Journal Linn. Soc. Zool. xii. p. 338) given an account of these fishes as found in India with the localities they inhabit; and it is therefore unnecessary to adduce further reasons for considering that we have the remains of three distinct and separate faunas existing amongst the living freshwater fishes of India. The *first*, among the ancient granitic hills of the Western Ghauts, extending into Ceylon, and also found on the Himalayas and in the Malay archipelago, shows some former connexion between these various points. That the fish themselves are of two races—the Palæarctic, which were derived from Asia (or the Mediterraneo-Persic subregion) west of the Indus; and the Malayan, which came through a continent now submerged beneath the Indian Ocean, a portion of which we, however, still discern in the Andamans and Nicobars. The *second* fauna, that of the plains, has an African element in it, and was likewise derived by a land communication west of the river Indus; but, due to some cause, its genera, unless widely distributed, give but a small proportion of existing forms. The *third* fauna, and by far the largest, is spread over the plains of India, and derived its existence through communication being formed with Burma and countries to the eastward; and these appear to have supplanted the prior African element from the waters of the plains.

Table showing the distribution of Genera in the various Subregions.

	Hindustan subregion.	Ceylonese subregion.	Himalayas.	Burma and Siam.	Malay archipelago.
Ambassis	1	1	0	1	1
Nandus	1	1	0	1	1
Badis	1	1	0	1	0
Pristolepis	0	1	0	1	1
Sciæna	1	1	0	1	1
Gobius	1	1	0	1	1
Sicydium	0	1	0	1	1
Periophthalmus	1	0	0	1	1
Eleotris	1	1	0	1	1
Rhynchobdella	1	1	0	1	1
Mastacembelus	1	1	1	1	1
Mugil	1	0	0	1	1
Ophiocephalus	1	1	1	1	1
Channa	0	1	0	0	0
Anabas	1	1	0	1	1
Polyacanthus	0	1	0	0	1
Osphromenus	1	0	0	0	1
Trichogaster	1	0	0	1	1
Etroplus	0	1	0	0	0
Macrones	1	1	0	1	1
Liocassis	1	0	0	0	1
Erethistes	1	0	0	1	0
Rita	1	0	0	1	0
Pangasius	1	0	0	1	1
Pseudeutropius	1	1	0	1	1
Olyra	1	0	0	1	0
Callichrous	1	1	0	1	1
Wallago	1	1	0	1	1
Silurus	0	1	1	1	1
Chaca	1	0	0	1	1
Clarias	1	1	0	1	1
Saccobranchus	1	1	0	1	0
Silundia	1	0	0	1	0
Ailia	1	0	0	0	0
Ailiichthys	1	0	0	0	0
Eutropiichthys	1	0	0	1	0
Amblyceps	1	0	0	1	0
Sisor	1	0	0	0	0
Gagata	1	0	0	1	0
Nangra	1	0	0	0	0
Bagarius	1	1	0	1	1
Glyptosternum	1	0	1	0	1
Euglyptosternum	1	0	0	0	0
Pseudecheneis	1	0	1	0	0
Exostoma	1	0	1	1	0
Belone	1	1	0	1	1
Cyprinodon	1	0	0	0	0
Haplochilus	1	1	0	1	1
Carried forward ...	42	25	6	35	29

Table (continued).

	Hindustan sub-region.	Ceylonese sub-region.	Himalayas.	Burma and Siam.	Malay archipelago.
Brought forward ...	42	25	6	35	9
Homaloptera............	0	1	1	1	1
Psilorhynchus	1	0	0	0	0
Discognathus............	1	1	1	1	0
Oreinus	0	0	1	0	0
Schizopygopsis	0	0	1	0	0
Schizothorax	0	0	1	0	0
Ptycobarbus	0	0	1	0	0
Diptychus	0	0	1	0	0
Labeo	1	1	1	1	1
Osteochilus	0	0	0	1	1
Dangila	0	0	0	1	1
Cirrhina	1	1	1	1	1
Semiplotus...............	1	0	0	1	0
Scaphiodon	1	1	0	0	0
Catla	1	0	0	1	0
Thynnichthys	1	0	0	0	1
Amblypharyngodon ...	1	1	0	1	0
Barbus	1	1	1	1	1
Nuria	1	1	0	1	0
Rasbora	1	1	0	1	1
Aspidoparia	1	0	0	1	0
Rohtee	1	1	0	1	0
Barilius	1	1	1	1	1
Danio	1	1	0	1	0
Perilampus	1	1	0	1	0
Chela	1	1	0	1	1
Botia	1	0	1	1	1
Acanthopsis	0	0	0	1	1
Somileptes	1	0	0	0	0
Lepidocephalichthys...	1	1	0	1	1
Acanthophthalmus	1	0	0	1	0
Apua	0	0	0	1	0
Jerdonia	0	1	0	0	0
Nemacheilichthys	1	0	0	0	0
Nemacheilus	1	1	0	1	1
Notopterus................	1	1	0	1	1
Amphipnous	1	0	0	1	0
Monopterus	0	0	0	1	1
Symbranchus............	1	1	0	1	1
Total	69	44	18	63	46

Description of two new Shells. By Sylvanus Hanley, F.L.S.

[Read December 19, 1878.]

Melania Limborgi, *Hanley*. *T.* oblongo-turrita, brevis, magis minusve crassa, olivaceo-flava. Anfractus pauci (circiter 8), magni, convexi, rapide crescentes; supremi læves, fascia spirali livida aliquantulum supra medium sæpius picti; inferiores costellis subdepressis (nonnumquam versus costellas basis acutiores angustas magisque distantes obsoletis) spiraliter ornati. Sutura distincta. Apertura ovato-elliptica, basi rotundata, circiter $\frac{3}{7}$ longitudinis testæ æquans, livida vel livido-fasciata; peristoma pallida; columella arcuata, macula livida picta, haud angusta. Long. 1 poll.

Hab. Mulé-it Range, Tenasserim (*Limborg*).

I am indebted for specimens of this shell to Colonel Godwin-Austen, who has requested me to name the species after its discoverer. The shell, which is very unlike any of its congeners in British India, displays no other painting than the narrow livid band which winds occasionally to the outer lip; it is probable, however, that additional ones are sometimes developed upon the body-whorl. The spire tapers quickly to its point, which latter is broken in all the examples I have studied. There are no longitudinal folds.

Leptomya gravida, *Hanley*. *T.* rhomboideo-obovalis, subequilateralis, fragilis, in medio tumida, ad rostrum concava, lactea, lineis tenuibus elevatis approximatis concentrice rugosa; plica dorsalis postica angulata margini dorsali fere attingens. Latus anticum rotundatum; latus posticum acuminatum, extremitas rostri centralis. Margo dorsalis antice subdeclivis, postice declivis; margo ventralis in medio subito tumidus, postice concavus. Apex declivis, acutissimus. Long. 1 poll.

Hab. —— ? (*Mus. Hanley*).

I have only seen a single valve (a left one, in very fine condition) of this peculiar-looking shell, which merely differs from a broken specimen from Arakan in the greater closeness of its raised lines and the nearer approximation of its Telliniform fold to the dorsal edge. It approaches the *L.* (*Neæra*) *cochlearis* of Hinds; but in that bivalve the raised lines are further apart, the posterior side is much longer, and the apex of the more tapering and more elongated beak rises above the middle. The rare *Scro-*

bicularia adunca of Gould is said to be a synonym of *Neæra cochlearis*, but is only known to me from its brief description in the 'Otia'; its characters do not harmonize with those of *L. gravida*.

On the Relations of *Rhabdopleura*.

By Professor G. J. Allman, M.D., LL.D., F.R.S., President.

[Read December 19, 1878.]

Some years ago I founded this genus for a very remarkable Polyzoal form dredged by Mr. Gwyn Jeffreys and the Rev. A. M. Norman from a depth of 90 fathoms in the Shetland seas*. My observations were made on specimens which had been preserved in spirit; and, as far as the condition of these would allow, some interesting results were obtained. G. Ossian Sars, however, had nearly at the same time the good fortune to dredge, from a depth of 120 fathoms, at Lofoten, off the Norwegian coast, examples of another species of the same genus; and he has been thus enabled to make a very careful and complete examination of the living animal†, and has in many important points rectified and supplemented the observations made by myself on spirit specimens.

At first sight *Rhabdopleura* would seem to find its proper place among the Phylactolæmata, to which it has the appearance of being allied by its crescentic lophophore and by the homologue of an epistome, if we so regard the remarkable shield-like organ which in the adult animal is situated between the two orifices of the alimentary canal.

The crescentic lophophore of *Rhabdopleura*, however, is very different from that of the hippocrepian or crescentic-disked Phylactolæmata, from which it is widely separated by its interrupted series of tentacles; while I am by no means ready to admit that the shield which constitutes so important a feature in this genus is the homologue of an epistome. A comparison of the more striking characters of *Rhabdopleura* with those of a typical poly-

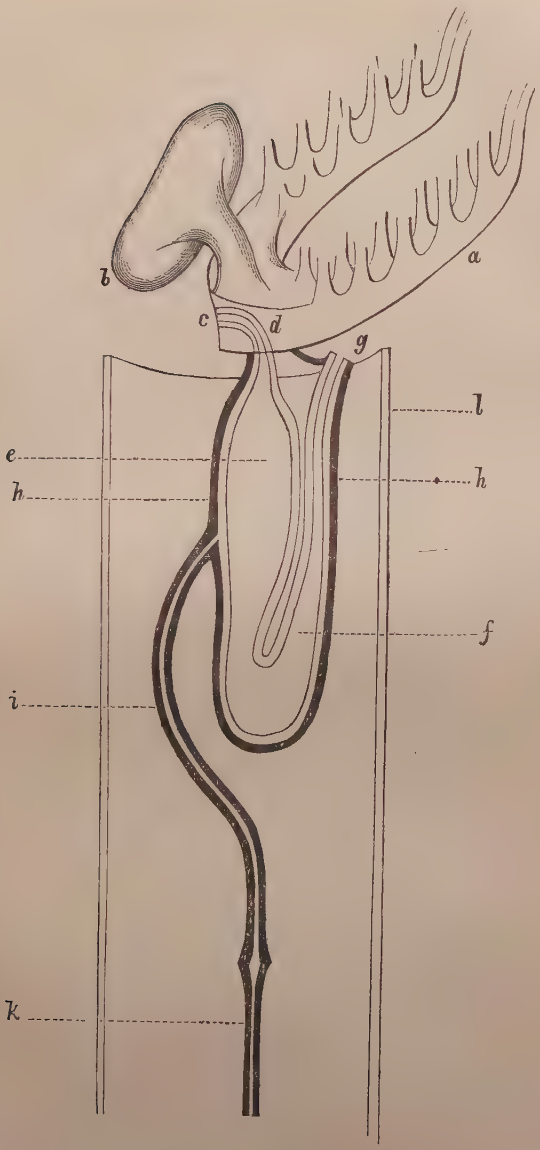
* Allman, on *Rhabdopleura Normani*. Quart. Journ. Micr. Sc., January 1869.

† G. O. Sars, on *Rhabdopleura mirabilis*. 'The University Programme' for 1869. Christiania, 1872. Reprinted in Quart. Journ. Micr. Sc., January 1874.

zoon will help us in arriving at a conclusion regarding these points.

The more important features by which *Rhabdopleura* differs from the typical marine Polyzoa will be found (1) in its crescentic lophophore; (2) in the tentacular series not being continued from the bases of the arms round the body of the lophophore; (3) in the lateral rather than terminal position of the mouth; (4) in the possession of a remarkable shield-like organ which is attached to the body of the lophophore between the mouth and anus; (5) in the possession of a chitinous rod which extends through the tubular cœnœcium, and gives attachment to one end of a contractile fleshy cord, which at the other end is fixed to the body of the polypide; (6) in the absence of an endocyst lining the cavity of the zoœcium, and in the further absence of a tentacular sheath.

A somewhat closer comparison of *Rhabdopleura* with an ordinary polyzoon will bring out some points of great interest, and will, I think, suggest the true significance of its singularly aberrant features. One of its most anomalous characters is the apparent absence of an endocyst and tentacular sheath. In the spirit specimens I failed to find any thing but what seemed the obscurest indications of them; and on these I would lay no stress, for the careful investigations of Sars on the living animal render it highly probable that neither endocyst nor tentacular sheath as usually understood are to be found. I believe, however, that *Rhabdopleura* is not without their homologues. These may be partly recognized in the fleshy contractile cord. This cord may be regarded as an endocyst which has become separated from the chitinous ectocyst, while the approximation of its walls has brought about the almost complete obliteration of its cavity. Where, however, the cord is attached to the polypide, it spreads in the form of a membrane over the whole of the alimentary canal. This membranous extension of the cord represents the anterior part of the endocyst with the tentacular sheath; and Sars has already suggested the possibility of the endocyst being here found. Posteriorly a still greater transformation has taken place; for in all the older parts of the cœnœcium we find the continuation of the cord in the condition of a chitinous rod, which, however, still presents in its lumen a trace of the original endocystal cavity. The endocyst in reçeding from the ectocyst carries with it the longitudinal muscular fibres which



Schematic and hypothetical diagram of *Rhabdopleura*. *a*. Lophophore, with origin of tentacles; *b*. Shield; *c*. Mouth; *d*. Œsophagus; *e*. Stomach; *f*. Intestine; *g*. Anal orifice; *h h*. Endocyst; *i*. Contractile cord; *k*. Commencement of the chitinous rod; *l*. External chitinous tube.

The representative of the endocyst is indicated by the broad dark line.

had entered into its composition; and we accordingly find the contractility of the endocyst retained by the cord*.

It is obvious that with these conditions there can be no invagination or evagination of the cystid walls; and the endocyst being anteriorly closely adherent to the walls of the polypide, while it is quite free from the ectocyst, the polypide in the act of protrusion carries out with it the whole of the anterior part of the endocyst without any evagination, and in retraction withdraws it without invagination into the tube of the chitinous ectocyst.

The obliteration of the endosarcal cavity need not surprise us; for in *Pedicellina* a nearly similar condition exists. Here also, as in *Pedicellina*, the absence of special retractor and parieto-vaginal muscles is a necessary result of the obliteration of this cavity.

The contractile cord-like portion of the endocyst offers a mechanism quite efficient for the retraction of the polypide. Its protrusion, in the absence of an endocystal cavity filled with a perigastric fluid, is not so easily explained. It is possible, however, that this may be aided by the elasticity of the cord, or, as Sars suggests, by the action of the great foot-like shield.

The determination of the true import of the shield is a matter of considerable difficulty; but I believe that what we know of it in connexion with the development of the polypide will tend to throw light on this question. In the earliest known stage of the bud, the shield already exists as a relatively very large organ. Indeed in this stage we can find nothing but the short thick cord-like endocyst carrying on its free end the great shield, which in *R. mirabilis* is, according to Sars, in the form of a moderately curved disk, while in *R. Normani* it has the curvature carried to such an extent as to make it resemble the two-valved fleshy mantle of a Lamellibranchiate.

Within the hollow of the curve the polypide is gradually developed. The shield becomes still larger, and continues for some time to exceed the growing polypide in size; but it is at last surpassed by this, and is finally reduced to the condition of a mere appendage of the polypide.

From this account of the origin of the shield and its connexion with the polypide, it is obvious that it cannot be the homologue of the epistome of the proper phylactolæmatous Polyzoa. Though our knowledge of the development of the epistome is by no means

* If such be the true interpretation of the contractile cord of *Rhabdopleura*, this cord cannot be homologous with the *funiculus* of *Alcyonella* &c.

complete, there is reason to believe that it is formed, like the lophophore and tentacles, by an introversion of the polypide walls in the region of the mouth, and that it has thus a significance entirely different from that of the shield of *Rhabdopleura*.

The formation of the chitinous ectocyst offers another question by no means easy of solution. We know that in the ordinary Polyzoa the ectocyst is a simple excretion from the surface of the endocyst, which is continually in contact with it. In *Rhabdopleura*, during the early stages of development of the polypide, the cord which represents the chief part of the endocyst is much thicker than at a later period, and may have then allowed the chitinous tube to be moulded on its surface. I am, however, well inclined to believe that the function of excreting the ectocyst devolves on the shield, which at an early period is relatively very large. It possesses, too, at this period a structure which might quite accord with such a function, being composed of elongated prismatic cells whose ends abut upon its outer surface. Indeed we can hardly avoid comparing it in this function, as well as in its form, with the shell-secreting mantle of a Lamellibranchiate mollusk.

If we bring together the morphological facts here adduced, we shall find that they give us a series which, so far as it goes, represents the life-history of *Rhabdopleura*. We have the endocyst, which, notwithstanding its anomalous condition, retains its normal faculty of originating new zooids by gemmation. In *Rhabdopleura*, however, the direct product of this faculty is a shield-like zooid, which by its bivalve form in *R. Normani* may even suggest the *Cyphonautus*-stage of *Membranipora*; and it is from this that we find emitted the ultimate bud which becomes directly developed into the proper polypide. The developmental phenomena here differ from those in *Alcyonella* mainly by the intercalation of a scutiform zooid between the cystid and the polypid. This zooid does not perish after the completion of the polypid, but remains as a subordinate appendage of the latter.

We are yet entirely ignorant of the sexual reproduction of *Rhabdopleura*; and until this is discovered our knowledge of its life-history must continue incomplete.

It must be now evident that whatever apparent resemblance there may be between *Rhabdopleura* and the proper Phylactolæmata, this genus essentially differs not only from the Phylactolæmata, but from all other Polyzoa to such an extent that it will

be necessary to place it in an independent section of the class. To this we may assign the name of POLYZOA ASPIDOPHORA. Indeed I regard *Rhabdopleura* as entitled to a rank at least as high as that of the ECTOPROCTA and ENDOPROCTA; and the ASPIDOPHORA will thus constitute a third great section of the class.

The hydroid affinity attributed to *Rhabdopleura* by the elder Sars, and accepted by his son, is based on a misconception of hydroid structure and development, as doubtless the distinguished Scandinavian zoologist would, on more mature consideration, have been among the first to admit*.

MOLLUSCA OF H.M.S. 'CHALLENGER' EXPEDITION.

III. TROCHIDÆ, viz. the Genera *Seguenzia*, *Basilissa*, *Gaza*, and *Bembix*. By the Rev. R. BOOG WATSON, B.A., F.L.S., &c.

[Read December 5, 1878.]

THE following group of genera are of considerable interest. They are nearly all from very deep water. Of the *Seguenzias*, two species are new; and some additional information of interest has been obtained regarding the genus. *Basilissa* is a new genus whose labial and basal sinus connect it with *Seguenzia*; while both genera present *Pleurotomaria* features hitherto unknown among the Trochidæ. *Gaza* is utterly distinct, not alone from these two genera, but from any thing known in the family, in which a reverted thickened lip is an entire anomaly. The genus *Bembix*, here proposed, is made for a new form of the Trochidæ, presenting an epidermis.

SEGUENZIA, *Jeffr.*

J. G. Jeffreys, Report on the Biology of the 'Valorous' cruise, Roy. Soc. Proc. No. 173, 1876, p. 200.

In all the species of this genus I have seen, besides the infrasutural sinus resembling that of *Pleurotoma*, there are two others —one, which is rather sharp and slight at the carina, and another, opener, on the base: between all of these the lines of growth curve out strongly towards the mouth. This might probably be accepted as a generic character. It is a feature very difficult to trace; but it certainly exists. In a perfect shell the mouth-edge

* See Ray Lankester in Quart. Journ. Micr. Sci., Jan. 1874.

would of course exhibit it; but all the specimens I have seen are more or less chipped.

The nacre of the shell is a feature that connects this genus with the Trochidæ. The nacreous layer is evidently not thick; and when the shell is young and perfectly fresh it is altogether so translucent that the nacre hardly appears as more than a pearly lustre; and in all cases it has more of the beauty of the actual pearl than that of the mother-of-pearl shell, but the nacreous layer is unmistakably present. The exterior calcareous layer is thin and very highly translucent, but still not glassy.

List of Species.

1. *Seguenzia formosa*, Jeffr.
2. *S. ionica*, W.
3. *S. carinata*, Jeffr.
4. *S. trispinosa*, W.

1. Seguenzia formosa, *Jeffr.*

St. 24. N. of Culebra Island. St. Thomas, Danish W. Indies. March 25, 1873. 390 fms. Several young and broken specimens.

St. 56. Bermudas. May 29, 1873. 1075 fms. *Globigerina*-ooze. 4 specimens, hardly full-grown.

Var. lineata, *W.*

St. 120? Pernambuco. Lat. 8° 73′ S., long. 34° 28′ W. September 9, 1873. 675 fms. Mud. 1 young specimen.

St. 122? Pernambuco. Lat. 9° 10′ S., long. 34° 50′ W. September 10, 1873. 350 fms. Mud. 1 young specimen.

J. G. Jeffreys, 'Valorous' Expedition, Roy. Soc. Proc. No. 173, 1876, p. 200:—From N. Atlantic, 1450 fms. Bay of Biscay, Spain, and Portugal, 718–795 fms. Gulf of Mexico, 325 fms. Fossil, Trapani, Sicily (*Seguenzia*).

Shell.—Small, conoidal; spire high; base inflated, white, glossy, with high spiral threads. *Sculpture.* Of spiral threads there are ten on the last whorl—one small, sharp, just at the suture; two, strong and sharp, of which the lower forms the basal carina; the upper, which issometimes even the more prominent, lies a little higher than halfway between the basal and the sutural spiral: on the base there are seven, very equal in strength and in distribution—the first lies somewhat remote from the basal carina, and is separated from it by a broad shallow furrow; the last lies pretty close to the pillar and twines round it. On the upper whorls only the sutural and supracarinal spirals are seen. There are microscopic spirals on all the surface. Longitudinals—there are many hair-like,

sharply projecting, flexuous, defining the lines of growth on the upper whorls, but these become very faint on the later whorls. *Colour* pure white with pearly translucency when fresh, but weathering opaque with a pearly gleam through the calcareous surface-layer. *Spire* high and conical, in some specimens a little depressed. *Apex* small, rounded, slightly tabulated, with the $1\frac{1}{4}$ embryonic whorl projecting, round, glossy, but slightly roughened. *Whorls* 8, of slow and regular increase, angulated above, sharply carinated, inflated on the base, which is also slightly angulated by the third infra-carinal spiral. *Suture* only doubtfully traceable (under the microscope) in the middle of the sutural spiral. *Mouth* perpendicular. *Outer lip* thin and sharp, not patulous, not descending, with an open not deep angular sinus near the suture, from which the line of the edge runs outwards uninterrupted across the second spiral, and forms a round projecting point, retreating again so as to form a second sinus, smaller and sharper, in the line of the basal carina, from which it again runs outwards into a rounded point in the exterior basal furrow, and from this again retreats, sharply changing its direction on the fifth spiral, and then again retreating, as before, to the sixth spiral, where it forms a third, open, obtuse-angled sinus, and then passes in regularly to the centre. *Pillar-lip* twisted, with a deep rounded sinus above, a strong twisted tooth at about two thirds of its length, another narrower rounded sinus below, and a sharp tooth at the point. The pillar is strengthened by a pad, which is spread out on the base so as to cover the seventh (counting from the suture) spiral, and envelopes the pillar so as to leave a minute furrow behind it, but ceases at the pillar-tooth. *Umbilicus* completely closed (but in some young specimens presenting a minute hole, see var. *lineata*, W.). H. 0·2. B. 0·14, least 0·12. Penult. whorl 0·04. Mouth, height 0·07, breadth 0·06.

Mr. Gwyn Jeffreys tells me (*in litt.*, Nov. 15, 1878) that he has got the operculum of this species, and that it "is ear-shaped, very thin, paucispiral (having only two whorls); the spire very small, excentric, and placed on the columellar side, thus resembling somewhat that of *Solarium* and *Adeorbis*"—a feature which, according to Quoy and Gaimard, is shared by *Euchelus*, Philippi's subgenus of *Trochus*.

To the young specimens from Pernambuco, var. *lineata*, W., I

have put a query; for though I cannot separate them, still the longitudinal sculpture is stronger, and there is an umbilicus.

2. Seguenzia ionica, *W.**

St. 24. Culebra Island. St. Thomas, Danish W. Indies. 390 fms. Mud. 7 young specimens.

St. 73. W. of Azores. June 30, 1873. Lat. 38° 30′ N., long. 31° 14′ W. 1000 fms. *Globigerina*-ooze. 2 specimens and fragment.

Shell.—Small, depressedly conical, sharply carinate, and spirally lirate, umbilicate, smooth. *Sculpture.* There is a sharp carina at the periphery; above this is a spiral liration formed by a sharp angulation, which on the upper whorls lies near the suture, but on the later whorls lies nearer the carina. The carina is margined below by a broad, shallow, round furrow, which is defined on its inner side by a sharp spiral thread. The umbilicus is defined by a sharp thread, outside of which is a shallow furrow and two or three more spiral threads; the centre of the base is nearly smooth, but has also some feeble spirals, which increase in strength toward the outside and toward the centre. Besides these, the whole surface is covered with sharp, not approximate, microscopic spirals. Longitudinals—there are numerous distinct lines of growth, which on the second whorl are like minute radiating spokes, and in the superior sinus (*i. e.* between the suture and the first spiral) are sharp and distinct, and more remote than elsewhere on the surface, except on the base round the umbilicus, where, though less sharp, they are even more distinct. *Colour* a dead chalky white, with an exquisite pearly nacre below the outside layer and within the shell. *Spire* low and scalar. *Apex* flattened, the embryonic $1\frac{1}{2}$ whorl, though somewhat tumid and large for the genus, being somewhat immersed. *Whorls* 7, of regular and slow increase until the last, which increases somewhat more rapidly; angulated above, tumid on the base, where (unlike *S. carinata*) the edge of the umbilicus is the most projecting part. *Suture* linear, very minute, but defined by a very slight shelf, which projects horizontally just below it. *Mouth* perpendicular, squarish, but too much broken for description. *Outer lip*, the lines of growth show it to have the same three sinuses as those described in *S. formosa.* *Pillar-lip* patulous, a little reverted, scarcely twisted, with a broad deep sinus above, a strong, but not sharp,

* So called from its resemblance to the volute of the Ionic capital.

twisted tooth projecting at about three fourths of its length, below which is a smaller sinus running out into a point at the extreme end of the pillar. *Umbilicus* large, funnel-shaped, deep, sharply defined by the edge of the base, the spiral of which runs out to the point of the pillar-lip. Within the umbilicus is a strongish undefined spiral furrow answering to the pillar-tooth, and the lines of growth are strongly defined. H. 0·18. B. 0·24; least breadth 0·21. Penultimate whorl 0·04.

This species differs from *S. carinata*, Jeffr., in being more depressed and broader, much more angulated and more lirate above, more tumid and lirate on the base, of which the carina is less flanged, and the most prominent part is the edge of the umbilicus, not the centre; here, too, the last whorl and the mouth are larger. The young of this species look disproportionately small and high.

3. Seguenzia carinata, *Jeffr.*

St. 73. West of Azores. June 30, 1873. Lat. 38° 30′ N., long. 31° 14′ W. 1000 fms. *Globigerina*-ooze. 1 specimen.

St. 78. San Miguel, Azores. July 10, 1873. Lat. 37° 24′ N., long. 25° 13′ W. 1000 fms. *Globigerina*-ooze. 1 specimen.

St. 85. Palma, Canaries. July 19, 1873. Lat. 28° 42′ N., long. 18° 6′ W. 1125 fms. Volcanic sand. 4 specimens, young.

St. 120. Pernambuco. September 9, 1873. Lat. 8° 37′ S., long. 34° 28′ W. 675 fms. Mud. 2 specimens, young.

J. Gwyn Jeffreys, Biol. Val. Cruise, Proc. Royal Soc. No. 173, 1876, p. 201. N. Atlantic, 690 fms. 'Porcupine' Expedition, 1870, Bay of Biscay, off Spain and Portugal, 718–1095 fms.

Shell.—Small, broadly conical, rounded on the base, sharply angulated, umbilicate, thin, polished, vitreous. *Sculpture.* There is a sharp circumbasal carina, which on the spire sometimes projects a little above the suture, and there is generally concealed by the succeeding whorl. In the middle of the whorls is a slight spiral thread, which on the earlier whorls is much stronger and somewhat lower in position than on the last; it defines the inferior edge of the generic sinus. The base is margined by a broad flat flange, and the edge of the umbilicus is defined by a fine sharp thread. Besides these there are some faint traces of microscopic spirals on the whole surface, especially on the base; and the basal sinus has on its outer edge more or less traces of a fine spiral thread. Longitudinals—there are many hair-like flexuous lines of growth. *Colour* glassy when fresh and young, in older shells

opaque white, but even then showing barely the faintest trace of pearly nacre. *Spire* conical, rather depressed, and with a slight convexity of its contour-lines. *Apex* very small and sharp, flattened on the one side, and with the minute embryonic 1½ whorl projecting roundly on the other. *Whorls* 7, of gradual increase, slightly convex above, flatter below, and a very little constricted above the sutural flange, whose edge is sharp below and rounded above. The base projects rather sharply from the inner side of the carinal flange, and then passes rather flatly across to the edge of the umbilicus, into which it slopes steeply. *Suture* linear and a very little impressed. *Mouth* perpendicular, almost square, but a little rounded both on the sides and at the angles. *Outer lip* sharp and thin, not patulous, not descending; the curves of its edge are similar to those described in *S. formosa*, there being three sinuses, one near the suture, a second at the carina, and a third toward the exterior of the base. *Pillar-lip* is patulous and a little reverted, scarcely twisted, with a broad deep sinus above, a strong twisted projecting tooth at about three fourths of its length, below which is a smaller sinus running out into a point at the extreme end of the pillar. *Umbilicus* large, funnel-shaped, deep, defined by a fine spiral thread, which runs out to the point of the pillar-lip; within the umbilicus is a shallow furrow answering to the pillar-tooth, and above is another spiral thread, stronger, but less sharp than that on the edge; the curved lines of growth are strongly defined in the umbilicus. H. 0·15. B. 0·17, least 0·15. Last whorl 0·037. Mouth, height 0·049, breadth 0·5.

This species is so thin and transparent that scarcely any trace of nacre can be recognized; but by carefully occluding the light on the outside, and thus having all the light reflected from the inside of the mouth, the pearly lustre is distinctly visible, especially at the outer upper corner.

4. SEGUENZIA TRISPINOSA, *W.**

St. 120. Pernambuco. September 9, 1873. Lat. 8° 37′ S., long. 34° 28′ W. 675 fms. Mud. 12 specimens, old and young.

Shell.—Small, high, conical, scalar, with three rows of tubercled lirations, umbilicate, thin, smooth. *Sculpture.* There is a sharp circumbasal carina, above this is a broad shallow furrow; about one third up the whorl is a narrow and blunt liration; a little more remote is a third, separated by a

* From the three rows of spinous lirations.

narrow, horizontal, flat surface from the suture. All these three lirations are ornamented with little tubercles or blunt spines, which are strongest on the highest thread, and there number about twenty-five on the body-whorl, on the second thread there are about twenty-eight. The base, which is rather flatly arched, has round the outside a flat surface hardly deep enough to be called a furrow, defined on the inner side by a clear narrow line, within which the curve of the base rises a little and has some faint spirals. The edge of the umbilicus is sharply defined by a fine line, outside of which is a broad shallow furrow bordered externally by a slight spiral; there is another narrower furrow, the outer side of which is the most projecting part of the base, but beyond this is rather flat and has some obsolete spirals. On the upper whorls the spirals are feeble and without tubercles, which only appear distinctly on the fourth whorl. Longitudinals—the flexuous lines of growth are very faint. *Colour* porcellanous when young and fresh, but weathering to a chalky white, with a pearly nacre below the thin surface and within the mouth, especially at the outer upper corner. *Spire* conical, high, scalar. *Apex* very small and sharp, flattened on the one side, and with the minute $1\frac{1}{4}$ embryonic whorl projecting tumidly on the other. *Whorls* $7\frac{1}{2}$, of gradual increase: the upper ones are rounded; the later flat below the suture, then angulated, then flat on the conical slope of the spire, and then very slightly constricted above the carina, very slightly rounded on the base, with a flat and slightly impressed, but sloping border round the outside, sharply angulated at the umbilicus. *Suture* linear, but strongly defined by the constriction and impressed angulation of the shell at that point. *Mouth* perpendicular, nearly square. *Outer lip* sharp and thin, not patulous, not descending. The curves are very faintly indicated by the lines of growth, but are similar to those described in *S. formosa*, Jeffr., there being three sinuses, one near the suture between the first and second spinose thread, a second, very small but sharp, at the carina, and a third toward the exterior of the base. *Pillar-lip* is patulous and reverted, with a furrow behind it, twisted, with a broad deep sinus above; a strong twisted projecting tooth at about two thirds of its length, below which is a smaller sinus running out into a point at the extreme end of the pillar; this point corresponds to the umbilical carina. *Umbilicus* more open than large, perpendicular and deep, being only slightly

narrowed by the reverted pillar-lip and by the corresponding ridge which twines spirally round the pit-wall. Below this ridge is a very strongly marked furrow, which corresponds to the pillar-tooth. H. 0·14. B. 0·15; least breadth 0·13. Last whorl 0·06. Mouth, height 0·05, breadth 0·06.

This species most resembles *S. carinata*, Jeffr., but is narrower, sharper, and the last whorl is larger: the suture is angulately impressed instead of being faintly linear; the spiral threads are stronger, and are picked out with tubercles; the base is more equably curved, the spirals on it are stronger: the umbilicus is smaller, and is more strongly defined, not only by the stronger carina, but by the extracarinal furrow. The pillar-tooth comes in higher up than in that species.

Basilissa, *W.*, gen. nov. (*βασίλισσα, queen.*)

Testa conica, carinata, umbilicata, margaritacea, anfractu ultimo superne sinuato; columella recta, parum obliqua, tenuis, superne excavata, inferne vix dentata, ad basin autem valde angulata; apertura rhomboidea, labiis nec conniventibus nec callo palatali junctis.

The special feature of this genus is the sinus in the outer lip near its junction with the body. In the presence of such a sinus it resembles *Seguenzia*, Jeffr., but differs from that genus in this, that *Basilissa* has a wide, open, shallow, not a deep-cleft sinus, is brilliantly nacreous, and lacks the sharp tooth on the pillar with the strongly marked sinus above and below it. It also wants the carinal sinus which all the species of *Seguenzia* I have examined present; and the basal sinus can scarcely be said to exist, though on the base the lines of growth change their direction markedly below the carina.

In form, in sculpture, and in its sinus this genus recalls M'Coy's genus *Platyschisma*, a Carboniferous fossil; but that belongs to the Solariidæ, and is distinguishable at once by the absence of the mother-of-pearl structure of shell, by its rounded mouth, and by its short pillar.

List of Species.

1. *Basilissa lampra*, W.
2. *B. simplex*, W.
3. *B. munda*, W.
4. *B. alta*, W.
5. *B. superba*, W.
6. *B. costulata*, W.

1. Basilissa lampra, *W.* (*λαμπρὸς, shining.*)

St. 246. July 2, 1875. Lat. 36° 10′ N., long. 178° 0′ E. Mid Pacific, east of Japan. 2050 fms. Grey ooze. 1 specimen.

Shell.—Thin, white, opalescent, smooth, faintly reticulated. In form slightly resembling a smallish *Zonites cellarius*, with a high concave spire, sharp apex, acute carina, angulated umbilicus, and rhomboidal mouth. *Sculpture.* Smooth, glossy, iridescent, with ten to twenty faint spiral threads on the upperside of the body-whorl; the last of these which joins the lip is much stronger than the others; a little remote and below is a thread forming the keel, below which, and nearer, are two other strong threads; round the umbilicus are also two strong threads; the intermediate space on the base is marked with eight to ten impressed spiral striæ. The interstices of the spirals are crossed by longitudinals, which are regular, fine, hair-like, but distinct and well parted; their curve on the surface below the suture shows the old sinus. On the base they are radiating and are crowded and irregular, except round the umbilicus, where in the first two or three striæ they are very sharp and distinct. On the upper whorls both the spirals and longitudinals are finer, but sharper, than on the last. *Colour* a greyish, horny, translucent, opalescent white. *Spire* raised, with a concave outline. *Apex*, which consists of the single minute embryonic whorl, is slightly exserted and sharp; it is quite smooth, but the spirals and longitudinals begin sharply immediately below it. *Whorls* 6½, of slow and regular increase except the last, which widens rapidly, depressed, quite flat, except the last, which is slightly rounded above, and still more slightly concave on the base, with an acute, but still rounded keel. *Suture* impressed on the body-whorl, but on the upper whorls sharply, though slightly, marginated below. *Mouth* a little oblique, rhomboidal, the basal and palatal lines being nearly parallel, while the outer and inner lip diverge downwards. *Outer lip* thin, not patulous, not descending, advancing at its junction with the body-whorl, and then retreating so as to form a shallow, broad, open sinus a little below the suture, acutely, but roundedly, angulate at the periphery, nearly flat on the base, with a very slight nick at the point of the pillar, where it joins the inner lip at a slightly obtuse angle. The *pillar-lip* is straight. It is a very little thickened, and is slightly porcellanous. It advances a little on the edge of the umbilicus; below this it is hollowed out by a receding curve, but advances again into a slight rounded projection just above its junction with the outer lip. In its whole direction it inclines slightly to the left. *Umbilicus* oblique edged, funnel-shaped, being wide in the mouth and deep, with straight converging sides. It is slightly

marked with lines of growth and a few faint spirals; while all the rest of the shell without and within is brightly opalescent, it is scarcely so at all. Height 0·3. B. 0·48, least 0·35. Penultimate whorl 0·08. Mouth, height 0·2, breadth 0·23.

This specimen is full-grown, and the animal is still within the shell, but the operculum is absent.

The species has a slight general resemblance to *Trochus* (subg. *Solariella*, S. Wood) *aureonitens*, A. Ad., but is utterly different, not only in its angulation, but in its sculpture.

2. Basilissa simplex, *W.* (*simplex.*)

St. 323. February 28, 1876. Lat. 35° 39′ S., long. 50° 47′ W. Off mouth of La Plata. 1900 fms. Grey mud. 1 specimen.

Shell.—A rather narrow cone, with a flat base, sharply angulated, small, thin, delicate, smooth, glassy, nacreous under a thin white calcareous surface. *Sculpture.* There are longitudinals, which are faint, hair-like, and sinuated, showing the old lines of growth. Of spirals, faint, rounded, and irregular, the whole surface has traces. At the bottom of each whorl is a flat puckered band, about 0·01 inch broad, whose upper edge projects sharply, especially on the upper whorls, and whose lower edge is a slight narrow flange which forms a sharp carina at the periphery. This band forms the upper border of the suture, which is further marginated below by two not contiguous rounded threads occupying the top edge of each whorl. The base is covered by about fourteen rounded ridges and furrows, which are rather stronger toward the centre, the last one, forming the edge of the umbilicus, being specially so. *Colour*, the surface is a dead slightly creamy white, formed by a thin calcareous layer through which the underlying nacre shines. *Spire* high and conical. *Apex* broken. *Whorls* 8 (reckoning the first two as broken), of slow and regular increase till the last, which enlarges rapidly; perfectly flat, with an upper and lower border, sharply angulated and carinated at the periphery, slightly convex, but still very flat on the base, with a bluntly angulated and carinated umbilical edge. *Suture* linear, almost invisible, marginated above and below. *Mouth* perpendicular, rhomboidal, with the body-pillar and basal edges nearly equal, and the pillar and outer lip nearly parallel. *Outer lip* sharp and thin, not patulous, not descending, advancing at its junction with the body-whorl, then retreating so as to form the broad open sinus, acute-angled at the

periphery, slightly arched across the base, nicked close to the point of the pillar. *Pillar-lip* arched, strengthened by a thin pad; reverted on the umbilicus so as to leave a slight groove behind it, with a slight tooth in front. From the body-whorl it bends very much over to the left, so as largely to cover the umbilicus, and then it curves over to the right to join the outer lip on the base at an obtuse angle. *Umbilicus* small, oblique-edged, funnel-shaped, nearly covered by the pillar-lip, and contracted within, scored with hair-like lines of growth. Height 0·255. B. 0·25, least breadth 0·2. Penultimate whorl 0·075. Mouth, height 0·12, breadth 0·11.

This is a narrower shell than *Basilissa alta*, W., less ornamented and with a smaller umbilicus. Than *B. munda*, W., this is a narrower shell, the flexuous longitudinals are stronger, the suprasutural band is stronger, and in that species the infrasutural band is wanting.

3. Basilissa munda, *W.* (*mundus.*)

St. 85. July 19, 1873. Lat. 28° 42′ N., long. 18° 6′ W. Off Palma, Canaries. 1125 fms. Fine volcanic sand. 1 young specimen.

Shell.—Broadly conical, flat on the base, sharply angulated, small, thin, delicate, smooth, glossy, nacreous under a thin white calcareous surface. *Sculpture.* There are longitudinals, which are very faint but still sharp, sinuated, showing the old lines of growth. Of spirals there are over the whole surface very faint traces. At the bottom of each whorl, about ·01 in. above the suture, is a sharp narrow thread, which on the last whorl is bordered below by a second, rather higher and sharper, which forms the carina, and which on the spire is buried by the overlap of the succeeding whorl. On the base there are about eleven fine spirals, within which is a strong furrow, and a projecting, crenulated, or rope-like thread forming the edge of the umbilicus. *Colour* opalescent, from the underlying nacre shining through the polished, thin, translucent calcareous layer of the surface. *Spire* high and conical. *Apex* flattened, with the minute smooth embryonic 1½ whorl slightly projecting. *Whorls* 6, of regular and slow increase (but the specimen is not full-grown); perfectly flat, the slope being scarcely broken by the suprasutural thread. *Suture* linear, almost invisible. *Mouth* perpendicular, irregularly rectangular, broader than high. *Outer lip* sharp and thin, with a slight open sinus; sharply angled at the periphery,

slightly arched across the base, apparently nicked at the point of the pillar. *Pillar-lip* arched, strengthened by a thin pad, reverted on the umbilicus so as to leave a groove behind it, with a slight tooth in front. From the body it bends very much over to the left, so as largely to cover the umbilicus; it then advances straight and is toothed in front. *Umbilicus* small, oblique-edged, with a crenulated margin. Height 0·13. Breadth 0·14, least 0·12. Penultimate whorl 0·03. Mouth, height 0·06, breadth 0·05.

Than *B. simplex*, W., this is a broader, smoother, less banded shell. Than *B. alta* it is lower, less ornamented, with a much smaller umbilicus.

4. BASILISSA ALTA, *W.* (*altus.*)

St. 24. Mar. 25, 1873. Culebra Island, St. Thomas, Danish W. Indies. 390 fms. Mud. 3 specimens, one full-grown.

St. 120. Sept. 9, 1873. Lat. 8° 37′ S., long. 34° 28′ W. Off Pernambuco. 675 fms. Mud. 1 young specimen.

Var. OXYTOMA, *W.*

Shell.—An equilateral cone, flat-based, sharply angulated. Small, thin, delicately sculptured. Nacreous under a thin, white, calcareous surface. *Sculpture.* There are longitudinals about 45, hair-like, strongly sinuated, flexuous, for they advance markedly on the periphery, where they are each ornamented by an elongated curved tubercle, and on the base they again retreat so as to form a sinus. On the earlier whorls these longitudinals are much more distinct than on the later, and each starts from a little bead, which lies close to the suture, but these beads are very feeble on the last whorl. In the intervals of the longitudinals and parallel to them are very faint lines of growth. Of spirals there are above the carina two stronger than the rest, with a sharp intermediate furrow; above these are several hair-like lines, which become feebler towards the middle of the whorl and stronger again above, the upper whorls presenting one in particular, which connects the row of infrasutural beads. On the base below the carina are four narrow and sharp spirals, followed by about eight, which are broader and flattened, and within there is one stronger than the rest, with about sixteen rounded beads, which crenulate the edge of the umbilicus. The furrows between these basal spirals are cut into little oblong pits by the longitudinals. *Colour* a dead creamy white, with the underlying nacre gleaming through. *Spire* high and conical.

Apex flattened, with the minute, smooth, $1\frac{1}{4}$ embryonic whorl somewhat tumidly projecting. *Whorls* $8\frac{1}{2}$, of slow and regular increase. In the earlier whorls there is a slight tumidity below the suture, a slight contraction in the middle, and a slight swelling round the base of each whorl. This last feature is feebly persistent in the later whorls, but otherwise these are flat. There is a sharp carinated angle, and the base is almost flat, with an angular tubercled umbilical edge. *Suture* linear, almost invisible. *Mouth* perpendicular, somewhat rectangular, and broader than high. *Outer lip* sharp and thin, not patulous, not descending, with a rather deep but broad and open sinus at the suture, forming a slightly acute angle at the periphery, where it advances very markedly, retreating immediately to form a sinus on the base, where it is barely arched. *Pillar-lip*, which is somewhat thickened, advances very little at its junction with the body, then retreats slightly so as to form a small sinus, bending at the same time a very little over the umbilicus. It has a sort of double point with a slight nick between them. It is very slightly reverted, and the umbilical groove behind it is very small. *Umbilicus* small, funnel-shaped, oblique-edged, crenate on the margin, and strongly scored within, and with an oblique spiral formed by the old points of the false pillar-end. Height 0·25. Breadth 0·24, least 0·22. Penultimate whorl 0·08. Mouth, height 0·09, breadth 0·1.

The variety from Pernambuco is characterized by the remarkable distinctness of its sculpture, whence its name. This species is a broader and much more ornamented form than *B. simplex* or *B. munda*.

5. Basilissa superba, *W.* (*superbus.*)

St. 184. E. of Cape York, Australia. Lat. 12° 8′ S., long. 145° 10′ E. 1400 fms. Grey ooze. 1 specimen.

Shell.—High, concavely conical, flat-based, sharply angulated; thin, finely reticulated, cream-coloured. Nacre very faint. *Sculpture.* Spirals, there are about twenty delicate threads, very nearly but not quite regular in thickness or distance, on the upper part of the last whorl; they slowly decrease in number on the previous whorls. The two (or three) which form the carina are thrown out a little on a projecting whitish fillet, which encircles the base of the whorls. This whitish fillet extends to the base, where it forms a narrow obliquely-corrugated edging. On the base there are about thirty spirals, more crowded, flattened, and irregular than above, and the edge of

the umbilicus is defined by another whitish fillet, ornamented with about thirty oblong beads. One or two smaller and more faintly beaded threads lie within the edge of the umbilicus. Longitudinals—there are of these on the last whorl about 120, flexuous, marking the lines of growth, rather stronger, more regular, and more distant than the spirals, which run over the top of them and form little white nodes at the crossings. The intersections of these two systems cut the whole surface into rhombic reticulations, whose breadth is about 0·011 and their height 0·006. The longitudinal threads themselves are about 0·005 and the spirals about 0·003 broad. On the base the longitudinals are flattened and spread out into undulations. *Colour* creamy, on a dull polished surface, with a very faint nacreous gleam, which is pearly within the mouth; the apex is ruddy. *Spire* high and conical, with slightly concave slopes; apex broken. On the upper whorls the longitudinals are strong, while the spirals are obsolete, except the carinal fillet, which projects bluntly above the suture. *Whorls* about 14, of very regular increase, very slightly convex, sharply acute-angled at the carina; on the base, flat at the outer edge and barely convex in the middle, with a slight dip in toward the edge of the umbilicus, which is strongly defined. *Suture* linear, defined by the white carinal fillet, and also on the lower whorls by being very slightly impressed. *Mouth* perpendicular, rhomboidal, the basal and palatal lines being parallel, the other two somewhat diverging and curved, broader than high. *Outer lip* sharp and thin, not patulous, not descending, with a shallow open sinus below the suture, below this, about the middle of the whorl, it advances with a rounded sweep, retreating sharply across the carina to form the open rounded basal sinus towards the outer edge of the base. *Pillar-lip* sharp and thin; it rises from the body a good way within the edge of the umbilicus. It retreats so as to form a sinus, and there it bends over a little on the umbilicus, and it forms a sharp angle projecting into a tooth at the extreme point of the pillar. *Umbilicus* strong, deep, abrupt, there being on the base only a very slight dip in towards it, and it is defined by the white-beaded fillet. Within, besides the two spiral lines, there are slight longitudinal striations, and the inner edge of the whorls twines like a staircase round it, but concealed by the over-curve of the pillar-lip. H. 0·75. B. 0·65, least 0·6. Penultimate whorl 0·16. Mouth, height 0·2, breadth 0·28.

The form of this shell connects it with *Basilissa alta*, *B. simplex*, and *B. munda*, and it distinctly has the sinuses of the genus: the layer of nacre is very faint; there is, however, a gleam of it through the surface-layer, and within the mouth, in a favourable light and protected from light coming through the shell, there is a distinct pearly lustre.

It has some resemblance to *Eutrochus gemmatus*, Reeve, in form and in its gemmed umbilicus; and, though much higher and more conical, recalls the *Solaria* of the group *Torinia* (Gray), especially *S. trochoides*, Desh.

6. Basilissa costulata, W.

St. 24. Mar. 25, 1873. Off Culebra Island, St. Thomas, Danish West Indies. 390 fms. Mud. Three rather young specimens.

Shell.—Small, depressedly conoidal, sharply angulated, flattish on the base, sharply and deeply umbilicated, a little porcellanous, flexuously ribbed. *Sculpture*. The whole surface is covered with longitudinal flexuous ribs, which are narrow, sharp, and uniform, and each is about 0·002 in. broad, and they are parted by intervals, which at the suture are twice and at the periphery thrice as broad as the ribs. There are about 40 of these on the last whorl. They are crossed by spirals, half the breadth of the ribs, running across the intercostal spaces and forming knobs on the ribs. Of these on the last whorl there are about seventeen, much closer-set and less uniform than the ribs; in particular the carinal spiral, which is very sharp, and the fourth and seventh above it, are stronger than the others; the last mentioned of these is especially so on the earliest whorls. On the base the longitudinals, though continued even into the umbilicus, become much less prominent and are no longer nodose; and the spirals, of which there are about fifteen, are closer-set, broader and flatter, except the first three below the carina, which are sharp and narrow. The whole base is pit-marked from the spiral interstitial furrows being cut up by the longitudinals. *Colour* dead white (on the base a little glossy) on the thin porcellanous surface, through which the nacreous layer behind gleams. *Spire* raised, with a very slightly concave outline. *Apex*, which consists of the minute smooth embryonic whorl and a half, is itself a little flattened, but rises sharply above the sculptured surface of the succeeding whorls. *Whorls* $5\frac{1}{2}$, of slow and regular increase till the last, which begins to enlarge rapidly. They are slightly

rounded above, very sharply angulated at the keel, and flattened on the base, with a bluntly angulated umbilical edge. *Suture* distinct, slightly impressed. *Mouth* perpendicular, square. *Outer lip* sharp, thickened by a slight internal remote callus, not patulous, not descending, advancing at its junction with the body-whorl and then slightly retreating so as to form the very shallow open sinus; right-angled at the periphery, flat on the base, where it retreats so as to form two rounded sinuses, making with the pillar an angle that is scarcely obtuse. *Pillar-lip* is straight, slightly thickened and reverted, so as to leave a slight groove behind it. It advances on the body-whorl, then retreats so as to form a slight sinus, bending at the same time shortly but sharply to the right into the umbilicus and then advancing straight forward, but a little toward the left, to its junction with the outer lip at the base. *Umbilicus* funnel-shaped, open-mouthed, oblique-edged, straight-sided, deep and contracted internally. Its edge is sharply defined by a spiral thread, and is obliquely scored by the longitudinal ribs; further in its walls are marked by hair-like lines of growth and faint spirals. Height 0·12. Breadth 0·14; least 0·11. Penultimate whorl 0·23. Mouth, height 0·063, breadth 0·061.

This species slightly resembles in sculpture the young of *Margarita striata*, Brod. (=*Trochus cinereus*, Couth., *nec* Da Costa), but in all details of form and ornamentation is very different. From *Trochus amabilis*, Jeffr., besides the generic features, it differs in the depressed spire, in the absence of the deep-cut suture, in the flatness of the base, and in all the features of minute sculpture.

GAZA, *W.*, gen. nov. (*γάζα, treasure.*)

Testa trochiformis, plane margaritacea, eleganter cælata, labio retroverso calloque margaritaceo incrassato; columella torta, directa, antice mucrone angulata, postice a labio penitus disjuncta, ad regionem autem umbilicalem in pulvinum margaritaceum complanata. Operculum rotundum, membranaceum, tenue, multispirale.

I wish to express by "plane" the sense of both *lucide* and *penitus*, the shell being both on the surface strikingly and throughout its whole substance entirely nacreous.

Whether this and all the other features enumerated above will prove constant is a question for time to determine. At present a new genus is inevitable; for this shell, though plainly one of the Trochidæ and of the Trochocochlea group, cannot possibly be

put into the genus *Trochus* in any of its divisions. In form it resembles most of all one of the West-Indian operculated pulmonates, such as *Alcadia*, while its exquisite nacre, its cancellated sculpture, its reflexed thickened lip, its nacreous umbilical pad, and its perpendicular externally mucronated pillar, separate it in the strongest way. In these circumstances I have yielded to the strongly expressed opinions of judges so trustworthy as Dr. Kobelt, of Frankfort, and Mr. Dall, of Washington, and take this as the type of a new genus.

1. Gaza dædala, *W.* (*δαίδαλος, variegated.*)

St. 174. August 3, 1874. Kandavu, Fiji. Lat. 19° 10′ S., long. 178° 10′ E. 610 fms. *Globigerina*-ooze. 1 specimen.

Shell.—Depressedly globose, with a convexly conical spire, thin, translucent, horny, nacreous in its whole texture, and iridescent on the surface, with a slightly reverted and narrowly thickened lip, a thin-edged twisted pillar, the point of which runs out into a bluntly mucronated angle. *Sculpture.* Longitudinals—the whole surface is covered with strong, puckered, oblique lines of growth, which are sharp-edged, but flattened, rather regular, with many minuter ones in the intervals. The longitudinals are cross-hatched with spirals which are stronger and more regular but not perfectly uniform, consisting of square threads and furrows of equal breadth, and both scored by the longitudinals; on the earlier whorls these spirals disappear before the longitudinals do; and on the base they become on the outside feebler, closer, and finer, in the middle broader and flatter, and stronger again toward the centre of the shell. *Colour* a delicate yellowish, with a horny translucency and exquisite iridescence, which under the lens appears brilliant. *Spire* high and slightly scalar. *Apex* very small, flatly rounded, the embryonic $1\frac{1}{4}$ whorl very slightly projecting. *Whorls* 7, of gradual increase, well rounded, the last slightly angulated below, and on the base flattened, but rather less so towards the mouth, where there is a slight contraction and downward turning of the whole whorl, without, however, any descending of the lip at its junction with the body. *Suture* very distinct, but not impressed. *Mouth* rather large, very oblique, semioval. *Outer lip* reflected and thickened by a strong but narrow, equal, rounded, white pearly callus, which almost disappears just at the upper corner, and which has a very slight furrow round its margin; it does not descend at all.

Inner lip—from the corner of the outer lip a very thin layer of nacre spreads out a little way across the body, but then ceases entirely. The pillar is spread out at its base as a confined, flattened, unevenly inclined, semicircular, iridescent umbilical pad, from the left corner of which the pillar proper projects, narrow-edged but rounded, twisted, straight, bending to the left, and advances into a sharply angulated, and, as seen from behind, even mucronated junction with the basal mouth-edge, to which the umbilical pad curving round the back of the pillar also attains. The inside is scored with the external sculpture, and is brilliantly iridescent. The umbilical pad is defined by a narrow furrow, and in front by a slightly tumid ridge, which is the least nacreous part of the whole shell. *Operculum* is membranaceous, horny, yellowish, with about six to seven turns, each strongly defined by a narrow line of thickening, and sharply scored with minute oblique radiating lines. H. 0·65. B. 0·87, least 0·7. Penultimate whorl 0·199. Mouth, height 0·43, breadth 0·41.

Unfortunately, though the operculum is preserved, nothing but traces of the animal remain within the shell.

BEMBIX, *W*., gen. nov. (*βέμβιξ, a top.*)

Testa conica, alta, carinata, basi inflata, umbilicata, tenuis, margaritacea epidermide tenui membranacea induta.

The remarkable feature of this genus is its being covered with a thin, extremely persistent, smooth, fibrous epidermis, like that of some of the *Helices*, a feature to which I know nothing similar in the family. The epidermis swells up and becomes pustulated in water. In form the shell recalls some of the *Cantharidus* group, but is thinner and on the base more tumid; the axis is perforated, and the pillar is thin, reverted, and merely angulated in front. It is very unfortunate that the shell, of which there is but one specimen, is not quite full-grown, so that the form of the umbilicus and, still more, of the mouth is very doubtful. The animal, too, and the operculum are both absent. Its separation from the Turbonidæ is thus not quite satisfactory. As to the name of the genus, I think the only objection that can be taken to it is that Philippi proposed the name *Bembicium* for one of the genera of Litorinidæ, but afterwards himself withdrew it for the prior name of *Risella*, Gray.

1. BEMBIX ÆOLA, *W*.

St. 232. May 12, 1875. Mosima, Japan. Lat. 35° 11′ N.,

long. 139° 28′ E. 345 fms. Sandy mud. 1 specimen, not quite full-grown.

Shell.—High, concavely conical, carinated, sculptured on the upper whorls, smooth or wrinkled below, thin, with a tumid lirated base, narrowly umbilicated, with a smooth epidermis, thin, but especially so on the base. More or less nacreous all over under a thin porcellanous upper layer. *Sculpture.* The first three whorls (after the embryonic apex) are reticulated by three sharp remote spirals, and rather stronger, slightly oblique longitudinals, which rise at their intersection into small sharp pyramidal tubercles; the interstices are a little broader than high. This system gradually dies out and leaves the surface smooth, only the row of infrasutural tubercles survives in an enlarged but depressed form, and springing from these some sinuous oblique and slightly irregular longitudinal puckerings appear on the last whorl, which is nearly bisected by the sharpish, slightly expressed, finely tubercled carina. This bisection of the last whorl arises from the great prolongation and tumidity of the base, on which, below the carina, are five narrow, equally parted, spiral threads, and two intraumbilical ones, which are more contiguous. Besides this larger system of sculpture, the whole surface is covered with minute, oblique, irregular, and interrupted puckerings of the epidermis. *Colour* a brownish yellow, but below the epidermis there is a thin pure white porcellanous layer, through which and the epidermis the sheen of the nacreous layer gleams. The base is whiter, the epidermis there being very thin. Inside the mouth is an exquisite roseate nacre. *Spire* high, with a slightly concave contour, the lines of which are hardly swollen out by the slight tumidity of the last whorl. *Apex* eroded, but evidently small. *Whorls* 7 or 8, of regular increase, quite flat, except the last, which is very slightly constricted below the suture, a very little tumid on the upper slope, sharply carinated but not much angulated at the suture, and very tumid on the base. *Suture* linear, strongly defined above by the square furrow lying between the lines of tubercles which marginate the suture above and below. On the last whorl it becomes slightly pouting, from the projection of the carina and the slight infrasutural constriction. *Mouth* nearly square, very little oblique in the line of its advance, but standing out a little obliquely to the axis of the shell. *Outer lip* thin, not descending. *Pillar-lip* thin, spread out broadly at its base over the

umbilicus, which it largely conceals, with a deep narrow furrow behind it. It advances thin and pointed, curving over to the right to its angular junction with the basal lip. *Umbilicus* defined by a spiral thread and with two other spirals within it. It is not so much small as concealed by the pillar-lip. H. 0·82. B. 0·63, least 0·53. Penultimate whorl 0·19. Mouth 0·4; breadth 0·38.

Perhaps *Trochus* (*Cantharidus*) *iris*, Humph., while totally unlike in most respects, nevertheless approaches this in form more than any other shell does.

Note as to the position of the Genus *Seguenzia* among the Gastropoda. By J. Gwyn Jeffreys, LL.D., F.R.S., F.L.S.

[Read February 6, 1879.]

The Rev. R. Boog Watson in a valuable paper, which was lately read before the Society, on some of the Mollusca procured by the 'Challenger' Expedition, included the genus *Seguenzia* in the *Trochus* family.

When I described that genus in the 'Proceedings of the Royal Society' (No. 73, 1876, p. 200), I said that it evidently belonged to the *Solarium* family; and I gave my reason for this opinion, to which I adhere. I am sorry not to agree with my friend Mr. Watson; but such difference of opinion is useful to science.

The chief points of distinction between the genera of Trochidæ and Solariidæ consist in the shell of the latter not being pearly or nacreous inside, and in the operculum being ear-shaped and few-whorled, with a lateral nucleus and excentric spire, as in the Littorinidæ. The operculum in the Trochidæ is circular and multispiral, with a central nucleus. I have fortunately succeeded in extracting the operculum from a small fresh specimen of *Seguenzia formosa*; and I find it to be ear-shaped, very thin, paucispiral (having two whorls only), the spire being very small, excentric, and placed on the columellar side. It resembles that of *Solarium* and *Adeorbis*, genera of the same family. Mr. Watson says that my account of the operculum represents "a feature, which, according to Quoy and Gaimard is shared by *Euchelus*, Philippi's subgenus of *Trochus*." Now all that Philippi remarks as to the operculum of *Euchelus* is, "der Deckel hat nach Quoy und Gaim. nur wenige Windungen;" but no mention is made of the shape of the operculum nor of its spire and nucleus. I have carefully examined

all the species, five in number, of *Euchelus* (*Aradasia*, Gray) in the British Museum, which show the operculum; and in every species the operculum is more or less circular, and the nucleus is central. In *A. cancellata* of Krauss and *A. baccata* of Menke the operculum is at first closely multispiral, as in other Trochidæ, although the last whorls more rapidly enlarge. Chenu describes the operculum of *Euchelus* as "subarrondi."

Seguenzia formosa has a nacreous exterior; but *S. carinata* and *S. elegans* have the same composition and appearance as the shells of *Solarium hybridum* and *Adeorbis subcarinatus*. All pearly shells do not necessarily belong to the *Trochus* family, *e.g. Turbo*, *Haliotis*, and *Nautilus*, to say nothing of *Anomia*, *Avicula*, and other bivalve shells.

The labial slit occurs not only in *Pleurotomaria*, but also in *Emarginula*, *Scissurella*, *Siliquaria*, and the Pleurotomidæ, as well as in *Seguenzia*.

It is to be hoped that any further doubt as to the systematic position of this remarkable genus will ultimately be cleared up by the discovery and examination of the soft parts of the animal. Deep-sea researches have auspiciously commenced: they must be continued and extended.

N.B. Two species of *Seguenzia* (viz. *formosa* and *carinata*) were fully described by me in the 'Annals and Magazine of Natural History' for April 1877, pp. 319 and 320; and it surely was superfluous for Mr. Watson to redescribe them at equal length. If every specimen of every species were described in the same way, the literature of natural history would become unnecessarily voluminous.

Observations on the Habits of Ants, Bees, and Wasps.—Part VI. Ants. By Sir JOHN LUBBOCK, Bart., M.P., F.R.S., F.L.S., D.C.L., LL.D., Vice-Chancellor of the University of London.

[Read February 6, 1879.]

ANTS.

Plant-hairs and Fur preventative against Ants climbing.

WHEN I first began keeping ants, I surrounded the nests by moats of water. This acted well; but the water required continually renewing, especially, of course, in summer, just when the ants were most active. At length, however, in considering the habits of ants and their relations to flowers, another plan suggested itself to me. The hairs by which plants are clothed are of various forms, and fulfil various functions. One is, I believe, to prevent ants and other creeping insects from climbing up the plants so as to obtain access to the flowers, and thus rob them of their honey.

It occurred to me, therefore, that instead of water I might use fur arranged so that the hairs pointed downwards. This I have found to answer perfectly; and I mention it specially because the same arrangement may be found practically useful in hot climates. It is, of course, very possible that in hot countries the fur might be open to objections which do not occur in England; and, again, the tropical species might be able to climb up the fur; but at any rate the experiment would be worth trying.

Workers freqently fertile as well as Queens, but produce usually Males.

It is generally stated that among ants the queens only lay eggs. This, however, is not correct.

Denny * and Lespès † have shown that the workers also are capable of producing eggs; but the latter asserted that these eggs never come to maturity. Forel, however, has proved ‡ that this is not the case, but that in some cases, at any rate, the eggs do produce young. Dewitz even maintains § that the workers

* Ann. & Mag. Nat. Hist. 2nd ser. vol. i. p. 240.

† Ann. des Sci. Nat. 1863.

‡ Fourmis de la Suisse, p. 329.

§ Zeit. f. wiss. Zool. vol. xxviii. p. 536.

habitually lay eggs, and explains the difference which on this view exists between the workers of ants and those of bees, on the ground that (as he supposes) the majority of ants die in the autumn, so that the eggs laid by the queens alone would not be sufficient to stock the nest in the spring; while among bees the majority survive the winter, and consequently the eggs laid by the queen are sufficient to maintain the numbers of the community. In reply to this argument, it may be observed that among wasps the workers all perish in the autumn, while, on the contrary, among ants I have proved that, at least as regards many species, this is not the case. Moreover, although eggs are frequently laid by workers, this is not so often the case as Dewitz appears to suppose. Forel appears to have only observed it in one or two cases. In my nests the instances were more numerous; and, indeed, I should say that in most nests there were a few fertile workers.

Among bees and wasps also the workers are occasionally fertile; but, so far as our observations go, it is a curious fact that their eggs never produce females, either queens or workers, but always males. The four or five specimens bred by Forel from the eggs of workers were, moreover, all males.

It would therefore be interesting to know whether the same is the case generally among ants; and my nests have supplied me with some facts bearing on the question. Most of my nests contained queens; and in these it would be impossible, or at least very difficult, to distinguish and follow the comparatively few eggs laid by the workers. Some of my nests, however, contained no queen; and in them therefore all the eggs must have been laid by workers.

One of these was a nest of *Formica cinerea*, which I brought back from Castellamare in November 1875. At that time it contained no eggs or larvæ. In 1876 a few eggs were laid, of which fifteen came to maturity, and were, I believe, all males. Last year there were fourteen pupæ, of which twelve came to maturity and were all males.

Again, in a nest of *Lasius niger*, kept in captivity since June 1875, there were in 1876 about 100 young; and these were, as far as I could ascertain, all males. At any rate there were about 100 males, and I could not find a single young female. In 1877 there were again some pupæ; but none of them came to maturity. Last year fifteen have come to maturity; and fourteen

were males. The other I could not find; but I have no doubt, from the appeacance of the pupa, that it was also a male.

Another nest of *Lasius niger*, captured in November 1875, in 1878 brought only one young ant to maturity; and this was a male.

Again, in a nest of *Formica fusca* captured in 1875, though in 1876 and 1877 eggs were laid and a few arrived at the pupa-state, none came to maturity. They were all, however, either males or queens, and, I have little doubt, were males. This year one came to maturity, and it was a male.

Another nest of *F. fusca*, captured in 1876, did not bring up any young in 1877. This year three larvæ came to maturity; and they all proved to be males. A nest of *F. fusca*, captured in 1877, in 1878 brought only one young one to maturity. This was a male.

In these species, then, as far as the evidence goes, it would seem that, as in bees, the workers can produce males only. On the other hand, I ought to add that in a nest of *Lasius flavus* captured in 1876 a number of workers were produced this year. In this species the larvæ live through the winter; but I can hardly believe they take two years in coming to maturity. Nor do I think the ants had access to any other larvæ; still I would not attach too much importance to this isolated case. In the case of bees we know that the queen is brought up on different food from the workers. Whether this is the case among ants, we have no knowledge. I am, however, disposed to believe it; because while hundreds, I might say thousands, of workers have been bred in my nests, and a large number of males, not a single queen has been produced in any one of them.

As to the Relations of Ants and their Domestics.

M. Lespès has given a short but interesting account of some experiments made by him on the relations existing between ants and their domestic animals, from which it might be inferred that even within the limits of a single species some communities are more advanced than others. He found that specimens of the curious blind beetle *Claviger*, which always occurs with ants, when transferred from a nest of *Lasius niger* to another which kept none of these domestic beetles, were invariably attacked and eaten. From this he infers that the intelligence necessary to keep Clavigers is not coextensive with the species, but belongs

only to certain communities and races, which, so to say, are more advanced in civilization than the rest of the species.

With reference to the statements of Lespès, I have more than once transferred specimens of *Platyarthrus* from one nest to another, and always found them received amicably. I also transferred specimens from a nest of *Lasius flavus* to one of *Formica fusca* with the same result. I even brought from the South of France some specimens of a different species, I believe *Typhlopone*, and put them in a nest of *Formica fusca*, where they are still living, and have brought up more than one brood of young. These species, however, occur in most ants' nests, while Clavigers are only found in some.

Longevity of Ants.

In my previous paper I have called attention to the longevity of ants, which has proved to be much greater than I had expected. One of my nests of *Formica fusca* was brought from the woods in December 1874. It then contained two queens, both of which are (May 1879) still alive. I have little doubt that some of the workers now in the nest were among those originally captured, the mortality after the first few weeks having been but small. This, however, I cannot prove.

In the following nests, however—viz. another nest of *Formica fusca*, which I brought in on the 6th June, 1875, one of *Lasius niger* on the 25th July, 1875, of *Formica sanguinea* (kindly sent me by M. Forel from Munich) on the 12th September, 1875, and of *F. cinerea* on the 29th November, 1875—there were no queens; and, as already mentioned, no workers have been produced. Those now living are therefore the original ones; and they must therefore now be between three and four years old.

In fact, though I lose many ants from accidents, especially in summer, in winter there are very few deaths.

On the mode of recognition of Friends.

It is clear, from the experiments recorded in the present and in my former papers, that the ants recognize their fellows in the same nest; but it is very difficult to understand how this can be effected. The nests vary very much in size; but in some species 100,000 individuals may be by no means an unusual number, and in some instances even this is largely exceeded. Now it seems almost incredible that in such cases every ant knows

every other one by sight. Neither does it seem possible that all the ants in each case should be characterized from those of other nests by any physical peculiarity.

It has been suggested that ants may recognize one another by scent. This, however, I think, cannot be the explanation. For instance, when intoxicated, ants were recognized; surely the whiskey must have obliterated any natural odour. Again, I have kept ants for forty-eight hours in an atmosphere strongly scented with musk; but when returned to the nest they were recognized without the least doubt or hesitation.

It has been suggested in the case of bees that each nest might have some sign or password.

The whole subject is full of difficulty. It occurred to me, however, that experiments with pupæ might throw some light on the subject. Although the ants of every nest, say of *Formica fusca*, are deadly enemies, still if larvæ or pupæ from one nest are transferred to another, they are kindly received, and tended with apparently as much care as if they really belonged to the nest. In ant-warfare, though sex is no protection, the young are spared, at least when they belong to the same species. Moreover, though the habits and disposition of ants are greatly changed if they are taken away from their nest and kept in solitary confinement, or only with a few friends, still, under such circumstances, they will carefully tend any young which may be confided to them. Now if the recognition were effected by means of some signal or password, then, as it can hardly be supposed that the larvæ or pupæ would be sufficiently intelligent to appreciate, still less to remember it, the pupæ which were intrusted to ants from another nest would have the password, if any, of that nest; and not of the one from which they had been taken. Hence, if the recognition were effected by some password or sign with the antennæ, they would be amicably received in the nest from which their nurses had been taken, but not in their own.

In the first place, therefore, I put, on the 2nd of September 1877, some pupæ from one of my nests of *Formica fusca* with a couple of ants from the same nest. On the 27th I put two ants, which in the meantime had emerged from one of these pupæ, into the nest at 8.30 A.M., marking them with paint as usual. At 9 they seemed quite at home; at 9.30, ditto; at 10, ditto; and they were nearly cleaned. After that I could not distinguish them.

On the 29th another ant came out of the pupa-state; and on

the 1st October at 7.45 I put her into the nest. She seemed quite at home, and the others soon began to clean her. We watched her from time to time, and she was not attacked; but, the colour being removed, we could not recognize her after 9.30.

On the 14th July last year (1878) I put into a small glass some pupæ from another nest of *Formica fusca* with two friends.

On the 11th August I put four of the young ants which had emerged from these pupæ into the nest. After the interval of an hour, I looked for them in vain. The door of the nest was closed with cotton-wool; so that they could not have come out; and if any were being attacked, I think we must have seen it. I believe, therefore, that in the meantime they had been cleaned. Still, as we did not actually watch them, I was not satisfied. I put in, therefore, two more at 5 P.M. At 5.30 they were all right; at 5.45, ditto, but one was almost cleaned. At 6 one was all right; the other was no longer recognizable, having been quite cleaned. At 6.30 also one was quite at home; the other could not be distinguished. At 7 both had been completely cleaned.

The following day I marked another, and put her in at 6 A.M. At 6.15 she was all right among the others, and also at 6.30, 7, 7.30, 8, and 9.30, after which I could no longer distinguish her.

Again, on the following day I put in another at 6.45 A.M. At 7 she was quite at home, and also at 7.15, 7.30, 8, and to 9.30, after which I did not watch her.

To test the mode in which the ants of this nest would behave to a stranger, I then, though feeling no doubt as to the result, introduced one. The difference was very striking. The stranger was a powerful ant; still she was evidently uncomfortable, started away from every ant she met, and ran nervously about, trying to get out of the nest. She was, however, soon attacked.

Again, on the 1st October some pupæ of *Lasius niger* were placed in a glass with five ants from the same nest.

On the 8th December I took three of the ants which had emerged from these pupæ, and at midday put them back into their old nest, having marked them by nicking the hind leg. Of course, under these circumstances we would not watch the ants. I examined the nest, however, every half hour very carefully, and am satisfied that there was no fighting. The next morning there was no dead ant; nor was there a death in the nest for more than a fortnight.

December 21. Marked three more in the same manner, and

put them in at 11.15 A.M. Looked at the usual intervals, but saw no fighting. The next morning there was no dead one outside the nest; but I subsequently found one of these ants outside, and nearly dead. I am, however, disposed to think that I had accidentally injured this ant.

Dec. 23. Painted three, and put them in at 10 A.M. At 11 they were all right, 12 do., 1 do., 2 do., 3 do., 4 do., 5 do. At 3 I put in three strangers for comparison: two of them were soon attacked; the other hid herself in a corner. The next morning I found two ants outside the nest; and they were two of the strangers. On the 31st I found the third stranger dead outside the nest. Found no other dead ant for some days.

Dec. 29. Painted three more of the ants from the pupæ separated on the 1st Oct., and put them in at 10.30 A.M. At 11 they were all right, 12 do., 1 do., 2 do. During the afternoon they were once or twice attacked for a minute or two, but let go again almost directly. The next morning I found one dead ant, but had no reason to suppose that she was one of the above three. The following morning there was again only one dead ant outside the nest; she was the third of the strangers put in on the 23rd as mentioned above. Up to the 23rd Jan. found no other dead one.

Jan. 3, 1879. Painted three more and put them in at 11.30 A.M. At 12 two were all right: we could not see the third; but no ant was being attacked. 12 do. 1, all three are all right; 2, do.; 5 do.

As already mentioned, for some days there was no dead ant brought out of the nest.

Jan. 5. Painted three more and put them in at 11.30 A.M. At 12 two were all right among the others; I could not find the third; but no ant was being attacked. 12.30 do., 1 do., 2 do., 4 do.

Jan. 6. Found two of them all right among the others. There was no dead ant.

Jan. 13. Painted three more and put them in at 12.30. At 1 they were all right. 2 do. 4, two were all right; I could not see the third, but she was not being attacked. The next morning, when I looked at the nest, one was being just carried, not dragged, out. The ant carried her about 6 inches and then put her down, apparently quite unhurt. She soon returned into the nest and seemed to be quite amicably received by the rest. Another one of the three also seemed quite at home. The third

I could not see; but up to the 23rd Jan. no dead one was brought out of the nest.

Jan. 19. Marked the last three of these ants and put them into the nest at 9.30 A.M. They were watched continuously up to 1. At that time two of them had been almost completely cleaned. One was attacked for about a minute soon after 11, and another a little later; but with these exceptions they were quite amicably received, and seemed entirely at home among the other ants.

Thus every one of these 32 ants was amicably received.

These experiments, then, seem to prove that ants removed from a nest in the condition of pupæ, but tended by friends, if reintroduced into the parent nest, are recognized and treated as friends. Nevertheless the recognition does not seem to have been complete. In several cases the ants were certainly attacked, though only by one or two ants, not savagely, and only for a short time. It seemed as if, though recognized as friends by the great majority, some few, more ignorant, or more suspicious, than the rest, had doubts on the subject, which however, in some manner still mysterious, were ere long removed. The case in which one of these marked ants was carried out of the nest, may perhaps be explained by her having been supposed to be ill, in which case, if the malady is considered to be fatal, ants are generally brought out of the nest.

It now remained to test the result when the pupæ were confided to the care of ants belonging to a different nest, though, of course, the same species.

I therefore took a number of pupæ out of some of my nests of *Formica fusca* and put them in small glasses, with ants from another nest of the same species. Now, as already mentioned, if the recognition were effected by means of some signal or password, then, as we can hardly suppose that the larvæ or pupæ would be sufficiently intelligent to appreciate, still less to remember it, the pupæ which were intrusted to ants from another nest, would have the password, if any, of that nest and not of the one from which they had been taken. Hence, if the recognition were effected by some password or sign with the antennæ, they would be amicably received in the nest from which their nurses had been taken, but not in their own.

I will indicate the nests by the numbers in my note-book.

On the 26th August last year, I put some pupæ of *Formica fusca*

from one of my nests (No. 36) with two workers from another nest of the same species. Two emerged from the chrysalis-state on the 30th; and on the 2nd September I put them, marked as usual, into their old nest (No. 36) at 9.30 A.M. At 9.45 they seemed quite at home, and had already been nearly cleaned. At 10·15 the same was the case, and they were scarcely distinguishable. After that I could no longer make them out; but we watched the nest closely, and I think I can undertake to say that if they had been attacked we must have seen it.

Another one of the same batch emerged on the 18th August, but was rather crippled in doing so. On the 21st I put her into the nest (No. 36). This ant was at once attacked, dragged out of the nest, and dropped into the surrounding moat of water.

Again, on the 14th July last year (1878) I put some pupæ of *Formica fusca* from No. 36 into a glass with three ants of the same species from nest No. 60.

On the 22nd I put an ant which had emerged from one of these pupæ into her old nest (No. 36) at 9.30 A.M. She was at once attacked. 10, she is being dragged about. 10.30 do.

Aug. 8. Put another ant which had emerged from one of these pupæ into her old nest (No. 36) at 7.45 A.M. At 8 she seemed quite at home among the others. 8.15 do., 8.30 do., 9 do. 9.30 do.

Aug. 9. Put two other young ants of this batch into their old nest (No. 36) at 7 A.M. At 7.30 they were all right. At 7.30 one of them was being dragged by a leg, but only, I think, to bring her under shelter, and was then let go. Young ants of this species, when the nest is disturbed, are sometimes dragged to a place of safety in this way. At 8.30 they were all right and nearly cleaned. After this I could not distinguish them; but if they had been attacked, we must have seen it.

Aug. 11. Put in another one as before at 8.30 A.M. At 8·45 she was all right. At 9 she was dragged by a leg, like the last, but not for long; and at 9.30 she was quite comfortable amongst the others. 10 do., 10.45 do., 12 do., 5 do.

Aug. 24. Put in the last two ants of this lot as before at 9.15 A.M. At 9.30 they were all right. 9.45 do. At 10 they were almost cleaned. At 10.30 I could only distinguish one; and she had only a speck of colour left. She appeared quite at home; and though I could no longer distinguish the other, I must have seen it if she had been attacked.

Thus, then, out of seven ants of this batch put back into their

old nest, six were amicably received. On the other hand, I put one into nest No. 60, from which the three nurses were taken. She was introduced into the nest at 8.15 A.M., and was at once attacked. 8.45, she is being dragged about. 9, do.; 9.15, do.; 9.30, do. Evidently therefore she was not treated as a friend.

Again, on the 14th July last year (1878) put some pupæ of *Formica fusca* from nest No. 60 with three ants from nest No. 36.

On the 5th August at 4 P.M. I put an ant which had emerged from one of these pupæ, into her old nest (No. 60). At 5.15 she seemed all right. They were already cleaning her; and by 4.30 she was no longer distinguishable. We watched the nest, however, carefully for some time; and I feel sure she was not attacked.

Aug. 6. Put another of this batch into nest No. 60 at 7.15 A.M. At 7.30 she is not attacked. At 8, one of the ants was carefully cleaning her. At 8.15 she was quite at home among the others. At 8.30 do., she was nearly cleaned. 9.30 do.

Aug. 8. Put in another as before at 7.45. At 8 she is all right. 8.30 do., 9.30 do., 9.45 do.

Aug. 9. Put in another as before at 7 A.M. At 7.30 she is quite at home among the others, and already nearly cleaned. At 8 I could no longer distinguish her; but certainly no ant was being attacked. 9 do.

Aug. 11. Put in another as before at 8 A.M. At 8.15 she is quite at home. 8.30 do., 9 do., 9.30 do., 10 do., 12.30 do.

Aug. 13. Lastly, I put in the remaining young ant as before at 7 A.M. At 7.15 she was all right. At 7.30 do. and nearly cleaned. At 8 I could no longer distinguish her; but no ant was being attacked.

Thus, then, as in the preceding experiment, these six ants when reintroduced into the nest from which they had been taken as pupæ, were received as friends. On the other hand, on the 5th August I put a young ant of the same batch into nest No. 36, from which the three nurses had been taken. She was introduced at 11 and was at once attacked. At 11.30 she was being dragged about, and shortly after was put to death. I then introduced a second; but she was at once attacked like the first.

Aug. 22. I put some pupæ of *Formica fusca* from nest No. 64 under the charge of three ants from No. 60. By the 7th September several young ones had emerged. I put two of them into nest No. 64 at 8.15 A.M. They were amicably received, as in the pre-

ceding experiments, and the ants began to clean them. At 8.30 they were all right. 8.45 do. At 9 they had been completely cleaned so that I could not distinguish them; but there was no fighting going on in the nest.

On the same day, at 9.45 A.M. I put into nest 64 two more as before. At 10 they were both quite at home among the other ants. 10.15 do., 10.30 do., 11 do., 12 do., 1 do. I then put in a stranger; and she was at once fiercely attacked.

Sept. 8. Put in two more of the ants which had emerged from the pupæ, as before, at 9.30 A.M. At 9.45 they were all right. 10 do., 10.30 do., 11 do., 11.30 do., 12 do., 1 do.

On the other hand, on September 14, I put one of these ants in the same manner into nest No. 60 at 6.30 A.M. She was at once attacked. At 6.45 she was being dragged about by an antenna. 7 do. At 7.30 she was by herself in one corner. At 8.30 she was again being dragged about. 9.30 do. The difference, therefore was unmistakable.

Lastly, on July 29 I put some pupæ of *Formica fusca* from out of doors under the charge of three ants from nest No. 36.

Aug. 3. Several had come out, and I put two of them into the nest of their nurses (No. 36) at 2 P.M. Both were at once attacked. At 2.45 they were being dragged about. 3 do. 3.30 one was being dragged about. 4, both were being attacked. Eventually one was turned out of the nest. The other I lost sight of.

Aug. 4. Put two more of this batch into nest No. 36. at 12.30. One was at once attacked. 1, one is being dragged about by an antenna. 2.30, both are being attacked. At 2.45 one was dragged out of the nest.

I then put back one of the old ones; as might have been expected, she was received quite amicably.

I then tried the same experiment with another species, *Lasius niger*. I took some pupæ from two of my nests, which I knew not to be on friendly terms, and which I will call 1 and 2, and confided each batch to three or four ants taken from the other nest. When they had come to maturity I introduced them into the nests as before.

They were taken from their nest on the 20th Sept.; and the results were as follows.

Pupæ from nest 1 confided to ants from nest 2.

Sept. 20. Put one of the young ones into nest 2 at 7.15 A.M.

Several at once threatened her. At 7.25 one of the ants seized her by an antenna, and began dragging her about. 7.30, she was still being dragged about. 8, do. 8.15, she is now being dragged about by three ants. 8.30, she is still attacked. 9, do. At 9.15 she was dragged out of the nest.

Sept. 23. Put two of the young ants into nest 1 at 9.15 A.M. One was at once attacked, and the other a few minutes afterwards. 9.45, both are attacked. 10, do. One is now dead and hanging on to a leg of assailant. 10.15, do. 10.45, both are still being dragged about.

At 11 A.M. I put into nest 2 three more very young ones. At 11.10 one was attacked. At 11.20 all three were being viciously attacked, and yet one was nearly cleaned. At 12 one was being attacked, one was alone in a corner, the other we could not find. At 12.10 one was dragged out of the nest and then abandoned, on which, to my surprise, she ran into the nest again, which no old ant would have done. She was at once again seized by an antenna. At 12.30 she was still being dragged about; the second was being cleaned. In this instance, therefore, I think two out of the three were eventually accepted as inmates of the nest.

Sept. 25. Put two of the young ones into nest 1 at 2.30 P.M. At 2.45 one was attacked, but not viciously. 3 do., 3.15 do. No notice was taken of the other, though several ants came up and examined her. 3.30, the first is not attacked, the second is almost cleaned. 4, the first has been again attacked, but not viciously, and moreover has been partly cleaned. The second is evidently received as a friend, and is almost cleaned. 4.30, they are both comfortably among the others and are almost clean. At 5 I could no longer distinguish them.

I now pass to the other batch, namely, pupæ from nest 2 with ants from nest 1.

Sept. 25. Put three of the young ants into nest 1 at 9.30 A.M. At 9.45 two were attacked, the third was by herself. 10 do. At 10.15 one made her escape from the nest. At 10.20 the third was attacked. At 10.30 one of them was dragged out of the nest, and then abandoned. At 10·50 the third also was dragged out of the nest.

I then put two of these ants and a third young one into nest 2. At 11.15 A.M. they seemed quite happy; but at 11.30 two were being dragged about; the third, who was very young, was, on the contrary, being carefully cleaned. At 12 this last one was undis-

tinguishable; of the other two, one was being attacked, the second was taken no notice of, though several ants came up to her. At 12.5 the first was dragged out of the nest and then abandoned; the second was being carefully cleaned. This went on till 12.20, when the paint was entirely removed.

Sept. 27. I put in three more of these young ants into nest 1, at 7.45 A.M. At 8 o'clock they seemed quite at home among the other ants. A few minutes after, one was being held by a leg; the other two seemed quite at home. At 8.30 one was almost cleaned, one I could not see. At 9 two of them were quite at home, but I could not see the third. At 9.30 they were both all but cleaned; and after that we were no longer able to distinguish them.

Thinking the results might be different if the ants were allowed to become older before being returned into their nests, I made no further observations with these ants for two months. I then took two of the ants which had emerged from the pupæ separated on the 20th of September, and which had been brought up by ants from nest 2, and on the 22nd of November I put them back at 12 in their old nest (that is to say, in nest 1), having marked them as usual, with paint. They showed no signs of fear, but ran about among the other ants with every appearance of being quite at home. At 12.15 do. At 12.30 one was being cleaned. At 12.45 both were being cleaned; and by 1 o'clock they could scarcely be distinguished from the other ants. There had not been the slightest symptom of hostility. After this hour we could no longer identify them; but the nest was carefully watched throughout the afternoon, and I think I can undertake to say that they were not attacked. When we left off watching, the nest was enclosed in a box. The next morning I examined it carefully to see if there were any dead bodies. This was not the case; and I am satisfied, therefore, that neither of these two ants was killed. To test these ants, I then, on the 24th of November, at 8.30 A.M., put into the nest two ants from nest 2. At 8.40 one was attacked; the other had hid herself away in a corner. At 9.15 both of the ants were being dragged about. At 9.35 one was dragged out of the nest and then released, and the other a few minutes afterwards. After watching them for some time to see that they remained outside, I restored them to their own nest. The contrast, therefore, was very marked.

Again, on Nov. 25, I took two ants which had emerged from

pupæ belonging to nest 2, removed on the 20th September, and brought up by ants from nest 1, and put them back into their old nest at 2 P.M. They were watched continuously until 4 P.M., but were not attacked, nor even threatened. The following morning one of them was quite well, the other one had probably been cleaned. We could not distinguish her; but if she had been killed, we must have found her dead body. I then at 10 A.M. put in two more. At 10.30 one of them was attacked for a moment, but only for a moment. With this exception neither of them was attacked until 2 o'clock, when one of them was again seized and dragged about for a minute or two, but then released again. We continued watching them till half-past 4, when they seemed quite at home amongst the others. On the other hand a stranger, put in as a test at 12, was at once attacked. It was curious, however, that although she was undoubtedly attacked, yet at the very same time another ant began to clean her.

The next morning we found one ant lying dead in the box outside the nest; and this turned out to be the stranger of yesterday. She had been almost cleaned; but there were one or two infinitesimal particles of paint still remaining, so that there could be no doubt of her identity.

The next day, Nov. 27, I put in three more of the ants derived from these pupæ at 10 A.M. At 10.30 they were all right, running about amongst the others. At 11 o'clock the same was the case; but whilst I was looking again shortly afterwards, one of them was seized by an antenna and dragged a little way, but released again in less than a minute. Shortly afterwards one of the others was also seized, but let go again almost immediately. At 1 o'clock they were all right, and also at 2. They had, however, in the meantime been more than once threatened, and even momentarily seized, though they were never dragged about as strangers would have been. At 3 o'clock I found one of them dead; but I think I must have accidentally injured her, and I do not believe that she was killed by the other ants, though I cannot speak quite positively about it. The other two were all right, and had been partly cleaned. At 6 one of them was running about comfortably amongst the rest; the other I could not distinguish; but certainly no ant was being attacked.

Nov. 28. I put in the last two ants from the above-mentioned batch of pupæ at noon. Like the preceding, these ants were occasionally threatened, and even sometimes attacked

for a moment or two; but the other ants soon seemed to find out their mistake, and on the whole they were certainly treated as friends, the attacks never lasting more than a few moments. One of them was watched at intervals of half an hour until 5 P.M.; the other we could not distinguish after 3, the paint having been removed; but we should certainly have observed it had she been attacked.

On the whole, then, all the 32 ants belonging to *Formica fusca* and *Lasius niger*, removed from their nest as pupæ, attended by friends and restored to their own nest, were amicably received.

What is still more remarkable, of 22 ants belonging to *F. fusca*, removed as pupæ, attended by strangers, and returned to their own nest, 20 were amicably received. As regards one I am doubtful; the last was crippled in coming out of the pupa-case; and to this perhaps her unfriendly reception may have been due.

Of the same number of *Lasius niger* developed in the same manner from pupæ tended by strangers belonging to the same species, and then returned into their own nest, 19 were amicably received, three were attacked, and about two I feel doubtful.

On the other hand, 15 specimens belonging to the same two species, removed as pupæ, tended by strangers belonging to the same species, and then put into the strangers' nest, were all attacked.

The results may be tabulated as follows:—

	Pupæ brought up by friends and replaced in their own nest.	Pupæ brought up by strangers. Put in own nest.	Pupæ brought up by strangers. Put in strangers' nest.
Attacked..........	0	7*	15
Received amicably..	32	37	0

I propose next season to make some more experiments of this nature; but even the above results seem to me very interesting. The differences cannot be referred to any difference of temperament in different nests. For instance, any idea that the specimens of *Formica fusca* experimented with in August and September, and amicably received, were so on account of the peaceable character of the nests, is disposed of by the facts. Thus specimens of *F. fusca* experimented with in August and September last were taken principally from two nests, numbered respectively 36 and 60. Now, while nest 36, in most cases, amicably received ants bred from its own pupæ but tended by ants from 60, it showed itself fatally hostile to ants from pupæ

* About three of these I do not feel sure.

born in nest 60, even when these had been tended by ants from nest 36. Nest 60, again, behaved in a similar manner, as a general rule, amicably receiving its own young, even when tended by ants from 36; and refusing to receive ants born in nest 36, even when tended by specimens from 60.

These experiments seem to indicate that ants of the same nest do not recognize one another by any password. On the other hand, if ants are removed from a nest in the pupa-state, tended by strangers, and then restored, some at least of their relatives are certainly puzzled, and in many cases doubt their claim to consanguinity. I say some, because while strangers under the circumstances would have been immediately attacked, these ants were in every case amicably received by the majority of the colony, and it was sometimes several hours before they came across one who did not recognize them.

Suggestions as to the Relation &c. of second "Knot" and Sting.

I have elsewhere suggested * that the existence of a second "knot" in the Myrmicidæ stands perhaps in relation with their possession of a sting. The late Fred. Smith indeed, describes *Œcophylla*, which has only one knot, as having a sting; and I have the above-cited memoir admitted that this would be a difficulty, though not, I think, a conclusive argument against the suggestion. Forel † has since pointed out that the sting of *Œcophylla* is rudimentary. He rejects my view, however, on the ground that some ants which have two knots have only a rudimentary sting, such as *Pheidole*; while some of the Poneridæ have a well developed sting and yet only one knot.

In does not, however, seem to me that these cases are conclusive. The stings of ants are obviously homologous with those of Bees and other Hymenoptera. The sting may therefore be said to be more ancient than the ant; and as we may also assume that the ancestors of ants at one time had an abdomen of the more usual type, *i. e.* without a knot, the existence of ants with a sting and only one knot, so far from being inexplicable, is just what might have been expected. They represent in this respect an archaic phase through which the ancestors of *Myrmica* must have passed. The existence of a second knot, giving

* Monthly Micros. Journ. Sept. 1877.

† Zeit. f. wiss. Zool. 1878, vol. xxx. p. 30.

greater mobility to the sting, might have been an advantage, and thus gradually produced in certain cases, without necessarily being developed in others, in which, perhaps, some other advantage was enjoyed.

The so-called stingless ants, as Forel and Dewitz* have clearly shown, possess in reality a rudimentary sting; and their ancestors obviously had a more developed one. Such cases, therefore, as *Pheidole* and *Atta*, to which M. Forel refers, represent cases in which, perhaps with reference to the powerful development of the mandibles, the sting has fallen partly into disuse, and consequently has diminished in size. On the other hand, the second knot having once been formed, has retained its existence. It will be observed also that the "knot" in the Formicidæ, where it is single, is much more elevated than in the Myrmicidæ where there are two knots, and consequently two sets of muscles moving the abdomen. Thus, while the Myrmicidæ have two sets of muscles acting on the abdomen, and the Formicidæ only one, the difference is to a certain extent neutralized by the fact that the muscles in the latter family are longer than in the Myrmicidæ. This accounts I think, for the elevation of the knot or scale in *Formica* and the allied genera.

As to Sounds emitted by Ants.

In 'Nature' for December is a letter from Mr. T. S. Tait, who, writing from Baroda, says that by means of the microphone "we have been able to hear the roar of a black ant when attacked by its companion." It is unfortunate that Mr. Tait does not mention the species, because some of the Mutillidæ make a sound which is audible even to the naked ear. Moreover the expression "attacked by its companion" is curious, and does not harmonize with the usual habits of ants. Still I am quite disposed to believe that ants do produce sounds.

In the previous paper I have mentioned that I was never able to satisfy myself that my ants heard any sounds which I could produce. On the other hand, I have tried unsuccessfully various experiments, in order to ascertain whether the ants themselves produced any sounds for the purpose of conveying signs or ideas. Prof. Tyndall was good enough to arrange for me one of his sensitive flames; but I could not perceive that it responded in any

* Zeit. f. wiss. Zool. vol. xxviii.

way to my ants. The experiment was not, however, very satisfactory, as I was not able to try the flame with a very active nest. Prof. Bell most kindly set up for me an extremely sensitive microphone: it was attached to the underside of one of my nests; and though we could distinctly hear the ants walking about, we could not distinguish any other sound.

It is, however, far from improbable that ants may produce sounds entirely beyond our range of hearing. Indeed it is not impossible that insects may possess senses, or rather sensations, of which we can no more form an idea than we should have been able to conceive red or green if the human race had been blind. The human ear is sensitive to vibrations reaching to 38,000 in a second. The sensation of red is produced when 470 millions of millions of vibrations enter the eye in a similar time; but between these two numbers vibrations produce on us only the sensation of heat; we have no special organs of sense adapted to them. But there is no reason in the nature of things why this should be the case with other animals; and the problematical organs possessed by many of the lower forms favour the suggestion. If any apparatus could be devised by which the number of vibrations produced by any given cause could be lowered so as to be brought within the range of our ears, it is probable that the result would be most interesting.

Observations on the Kindness of Ants.

In my previous paper I have given various cases which seem to show that ants are not so uniformly humane as the descriptions of previous writers would seem to imply. Some of those who have done me the honour of noticing my papers have assumed that I disputed altogether the kindly feelings which have been attributed to ants. I should, however, be very sorry to treat my favourites so unfairly. So far as I can observe, ants of the same nest never quarrel. I have never seen the slightest evidence of ill-temper in any of my nests: all is harmony. Nor are instances of active assistance at all rare. Again, indeed I have myself given various cases showing care and tenderness on their part.

In one of my nests of *Formica fusca* was a poor ant which had come into the world without antennæ. Never having previously met with such a case, I watched her with great interest; but she never appeared to leave the nest. At length one day I found her wandering about in an aimless sort of manner, and apparently

not knowing her way at all. After a while she fell in with some specimens of *Lasius flavus*, who directly attacked her. I at once set myself to separate them; but whether owing to the wounds she had received from her enemies, or my rough, though well-meant handling, or both, she was evidently much wounded, and lay helplessly on the ground. After some time another *Formica fusca* from her nest came by. She examined the poor sufferer carefully, then picked her up tenderly and carried her away into the nest. It would have been difficult for any one who witnessed this scene to have denied to this ant the possession of humane feelings.

Again, if an ant is fighting with one of another species, her friends rarely come to her assistance. They seem generally (unless a regular battle is taking place) to take no interest in the matter, and do not even stop to look on. Some species, indeed, in such cases never appear to help one another; and even when this is the case, as for instance in the genus *Lasius*, the truth seems to be that several of them attack the same enemy—their object being to destroy the foe, not to save their friend.

Wasps and Bees.

Further Experiments as to their Knowledge of Colour, &c.

The experiments recorded in one of my previous papers (Journ. Linn. Soc. vol. xii. p. 510) tend to indicate that wasps are less guided by colour than bees. I thought, however, that it would be well to make some more experiments on the subject. On the afternoon, therefore, of the 1st September I put a wasp to some honey on a slip of glass placed over red paper, and, continually supplying fresh honey, allowed her to keep on coming till the 5th. I then moved the paper and the honey about 15 inches, putting another drop of honey on another slip of glass, over green paper, in the old place. She returned to the honey on the green paper. I then replaced the honey and red paper as before, and she came back quite straight to it. I then again moved it, and put honey on blue paper in the old place. She returned, however, quite straight to the honey, without taking any apparent notice of the change of colour. Sept. 7th, I moved the honey and paper about a foot, and put a drop of honey on glass over blue paper in between. She went to the honey on the blue paper. I then let her come again to the honey on the red three or four times, and then as before moved the paper about a foot, and put another drop of

honey over it, placing the old honey on yellow paper in between. She came to the honey on the red paper, but after feeding for about half a minute left it, to try that on the yellow.

I may mention that other observations of the same kind gave similar results; but it is perhaps hardly worth while to give more details.

Indeed, while hive-bees were generally contented with any honey I gave them, wasps showed a very different disposition, and, if there were several drops of honey near one another, flew frequently from one to the other, as if to make sure which they liked best.

Conduct towards their Friends.

With reference to the behaviour as regards comrades, I may observe that the results entirely confirmed those previously arrived at. For instance, a wasp observed and fed from the 7th to the 12th Sept. did not bring more than three or four friends during the whole of that time.

Contributions to the Ornithology of New Guinea. By R. Bowdler Sharpe, F.L.S., F.Z.S., &c. Part V.—On recent Collections from the Neighbourhood of Port Moresby, S.E. New Guinea.

[Read March 20, 1879.]

The collection described in the present paper was formed by Mr. Kendal Broadbent, a well-known Australian naturalist, in the vicinity of Port Moresby and in the interior. It is one of the most important that has been made by the English travellers in South-eastern New Guinea; and it will be interesting to compare the species here enumerated with the forthcoming account of Signor D'Albertis's collections from the Fly River. It may be noticed that in this paper a Parrot of the genus *Aprosmictus* is described, which is closely allied to another species from the Fly River, but yet appears to be distinct, offering a parallel case to the two Crowned Pigeons of Southern New Guinea, where we find *Goura Albertisi* inhabiting the Port-Moresby district replaced by *G. Sclateri* on the Fly River. The same mountain-fauna seems to extend from the latter locality along the southern part of New Guinea, at least as far as the mountains in the interior of Port Moresby, if we may judge by the presence of such birds as *Drymœdus Beccarii* and *Cinclosoma ajax*, which occurs in both Signor D'Albertis's and Mr. Broadbent's collections. When these moun-

tains are more thoroughly explored, it will doubtless be found that they contain a certain number of species closely allied to others from the mountains of the north-west, and in some cases even identical with the latter. At present, however, the affinities of the south-eastern species seem to lie with those of the Aru Islands where they are not Australian, as by far the majority of them really are. The discovery of two species of green-shouldered *Aprosmictus*, related to the fine *Aprosmictus insignissimus*, Gould, of Australia, and of a species of the peculiar Australian genus *Cinclosoma*, strengthen the Australian affinities of the avifauna of South-eastern New Guinea.

In the present paper I have also taken the opportunity of correcting some errors which have crept into my accounts of the collections made by Mr. Stone and Dr. James in the same locality and published in the Society's Journal.

Note.—Since the present communication was read, I have received from Mr. Ramsay a copy of his recent paper, laid before the Linnean Society of New South Wales on the 30th of last September, entitled "Contributions to the Zoology of New Guinea," parts 1 & 2 (Journ. Linn. Soc. N. S. W. iii. pp. 241–305). In this paper Mr. Ramsay describes the Parrot and Flycatcher which I considered to be new to science; and consequently my specific names must be suppressed. I refer to Mr. Ramsay's paper in the accompanying text.

1. Astur torquatus (*Temm.*); *Sharpe, Mitth. Dresden*, iii. p. 355.—Urospizias torquatus, *Salvad. Ann. Mus. Civic. Genov.* xii. p. 38.—Astur Sharpii, *Ramsay, l. c.* p. 248.

Mr. Broadbent's collection contains a beautiful adult bird, measuring 10·3 inches in the wing. As in the case of Mr. Stone's specimen recorded by me in the 'Proceedings' of this Society, the thighs and under tail-coverts are both barred with rufous.

2. Harpyopsis novæ-guineæ, *Salvad. Ann. Mus. Civic. Genov.* xii. p. 36; *Sharpe, Mitth. Dresden*, iii. p. 355, pl. xxix.

A very fine specimen collected by Mr. Broadbent bears the following label:—"*Male*: eyes dark brown. Fairfax Harbour, Port Moresby. Scrub bird." It measures as follows:—Total length 31 inches, culmen 2·7, wing 18·6, tail 15·5, tarsus 5·2.

3. Hieracidea orientalis (*Schl.*); *Sharpe, Cat. B.* i. p. 422.

An example in Mr. Broadbent's collection. The present is the first record of the occurrence of a *Hieracidea* in New Guinea; and

I cannot find any difference between the specimen from Port Moresby and others from Australia in the British Museum.

4. APROSMICTUS CHLOROPTERUS, *Ramsay, l. c.* p. 251.—A. Broadbenti, *Sharpe, Ann. & Mag. Nat. Hist.* April 1879, p. 313.

Adult male. General colour above blackish, with a slight greenish wash, the scapulars like the back; head all round crimson, with the exception of the nape and hind neck, which are bright blue, this colour extending on to the upper part of the mantle; lesser wing-coverts along the edge of the wing blackish like the back, with a very faint wash of blue; the inferior lesser coverts and the whole of the median series bright yellowish green, forming a large shoulder-patch; greater wing-coverts dark like the back; bastard wing, primary-coverts, and primary quills rather brighter green externally, blackish on the inner web; the inner secondaries darker, and becoming blacker as they adjoin the scapulars; lower back, rump, and upper tail-coverts deep blue; tail dull blackish, with a slight greenish gloss on the two centre feathers, the rest washed with blue externally; sides of face, throat, and entire under surface bright crimson; the under tail-coverts blue-black, tipped with the same crimson as the breast; under wing-coverts deep blue, the greater series and the lower surface of the quills black.

Closely allied to *A. callopterus* of the Fly River, but having the nape blue as well as the mantle, whereas the whole head is red in the above-mentioned species. *A. chloropterus* is also a slightly smaller bird.

5. EOS FUSCATA, *Blyth*; *Salvad. Ann. Mus. Civic. Genov.* x. p. 34; *Ramsay, l. c.* p. 253.

A numerous series in Mr. Broadbent's collection, as well as in Mr. Goldie's.

6. NASITERNA KEIENSIS, *Salvad. Ann. Mus. Civic. Genov.* x. p. 26; *Gould, B. New Guinea,* part vi.—N. pusilla, *Ramsay, l. c.* p. 251.

A specimen was in Mr. Broadbent's collection, and another in Mr. Goldie's. As far as I can judge without actually comparing specimens, these little Pygmy Parrots appear to belong to the species described by Count Salvadori from the Ké Islands.

7. SCYTHROPS NOVÆ-HOLLANDIÆ, *Lath.*; *Sharpe, Journ. Linn. Soc.* xiii. p. 492; *Ramsay, l. c.* p. 259.

According to Mr. Petterd, in his notes appended to Mr. Stone's collection (*cf.* Sharpe, *l. c.*), the Channel-bill Cuckoo was generally distributed near Port Moresby. The first specimens that I have seen from that locality have now come to hand, the species being represented in Mr. Broadbent's and Mr. Lawes's collections, while several specimens are in Mr. Goldie's.

8. Centropus nigricans (*Salvad.*).—C. spilopterus, *Sharpe, Journ. Linn. Soc.* xiii. p. 490 (*nec Gray*); *Ramsay, l. c.* p. 258.—Polophilus nigricans, *Salvad. Ann. Mus. Civic. Genov.* xiii. p. 463.

The number of specimens which I have now seen of this Cuckoo, bearing out Count Salvadori's characters, convince me that I was wrong in referring the bird to *C. spilopterus* of the Ké Islands.

9. Tanysiptera sylvia, *Gould*; *Sharpe, Journ. Linn. Soc.* xiii. p. 493; *Salvad. Ann. Mus. Civic. Genov.* x. p. 303.—T. Salvadoriana, *Ramsay, l. c.* p. 259.

In Mr. Broadbent's collection were several examples, which appear to be quite identical with Cape-York specimens.

10. Tanysiptera microrhyncha, *Sharpe, Journ. Linn. Soc.* xiii. p. 311.—T. galatea (pt.), *Salvad. Ann. Mus. Civic. Genov.* x. p. 302.—T. galatea, *Ramsay, l. c.* p. 259 (*nec Gray*).

I have now examined a large series of the Racket-tailed Kingfisher in the collections both of Mr. Goldie and Mr. Broadbent, and I find the character of the small bill holds good. A certain difference is seen in the blue coloration of the head, some specimens having a rich cobalt-brown, inclining to silvery cobalt only on the edges: this is the most plentiful form, and agrees with the type of the species in the Museum. In Mr. Broadbent's collections, however, was a beautiful bird, of the same size as *T. microrhyncha*, but differing in having the back strongly washed with purplish blue, the head and wing-spot rich silvery cobalt. This may be the very old male bird; and I do not propose to describe a new species from a single example.

11. Dendrochelidon mystaceus (*Less.*).—Macropteryx mystacea (*Less.*); *Salvad. Ann. Mus. Civic. Genov.* x. p. 311; *Ramsay, l. c.* p. 265.

One specimen collected by Mr. Broadbent, and two in Mr. Goldie's collection.

12. Gymnocorax senex (*Less.*); *Sharpe, Cat. B.* iii. p. 50.

A specimen in grey plumage in Mr. Broadbent's collection.

13. Ptilorhis Alberti, *Elliot*; *Sharpe, Cat. B.* iii. p. 156.

Mr. Broadbent has sent a pair of male birds, which I refer to this species. The one retained for the Museum collection measures as follows—total length 11·8 inches, culmen 2·1, wing 7·55, tail 4, tarsus 1·7. It will be seen that these dimensions differ a little from those given by me in the 'Catalogue of Birds;' and the specific differences of the *males* of *P. Alberti* and *P. magnifica* become somewhat modified when the bird from Southern New Guinea is considered. As, however, the females of the two species are quite different, it will be interesting to examine this sex of the present bird from its new locality. Mr. Ramsay, who has the latter birds in his hands, declares them to be *P. magnifica.*

14. Pinarolestes megarhynchus (*Q. & G.*); *Sharpe, Cat. B.* iii. p. 295.—Colluricincla megarhyncha, *Ramsay, l. c.* p. 280.

A single specimen in Mr. Broadbent's collection.

15. Graucalus subalaris, *Sharpe, Mitth. k. zool. Mus. Dresden*, Heft iii. p. 364; *id. Cat. B.* iv. p. 26.—Campephaga Boyeri, *Ramsay, l. c.* p. 284.

An adult male in Mr. Broadbent's collection.

16. Edoliisoma nigrum (*Garn.*); *Sharpe, Cat. B.* iv. p. 45.—E. melas, *Ramsay, l. c.* p. 283.

An adult male in Mr. Broadbent's collection, and a female in Mr. Goldie's. This species was also contained in Mr. Stone's collection, but was omitted by accident from the list given by me.

17. Micrœca flavovirescens, *Gray, Sharpe, Cat. B.* iv. p. 125; *Ramsay, l. c.* p. 272.

In Mr. Broadbent's collection.

18. Pœcilodryas placens.—Eopsaltria placens, *Ramsay, l. c.* p. 272.—P. flavicincta, *Sharpe, Ann. & Mag. Nat. Hist.* April 1879, p. 313.

Adult. General colour above yellowish green; the wing-coverts, quills, and tail-feathers dusky sepia-brown, edged with the same colour as the back; head and nape dark grey, with slight indications of dusky centres to the feathers of the crown; the lores, sides of face, and ear-coverts dark grey, the latter blackish; fore part of cheeks and a large chin-spot dark grey, the latter tinged with green where it joins the throat, which, with the hinder part of the cheeks and sides of the neck, is bright yellow; fore neck

chest, and sides of upper breast yellowish green, darker on the latter; remainder of under surface of body bright yellow; under wing-coverts and axillaries whitish, washed with yellow, with a dark greenish patch near the outer edge of the wing; quills dusky brown below, whitish along the basal edge of the inner web; bill black; feet pale yellowish in skin.

This appears to me to be a very distinct species of *Pœcilodryas*, nearer to *P. capito* and *P. leucops* than to any other, but quite different from either. The 'Key to the Species' in my Catalogue (vol. iv. p. 241) will require modification as follows:—

b. Abdomen yellow.	
c'. Lores with a large white spot &c.	{ *leucops.* *capito.*
d'. Lores yellow, as also entire under surface; head olive-yellow like the back	*papuana.*
e'. Lores grey, like the rest of the head, sides of face, and chin; above olive-yellow; below bright yellow, with the fore neck and chest green, forming a broad band across the chest	*flavicincta.*

19. Rhipidura maculipectus, *Gray*; *Sharpe, Cat. B.* iv. p. 326.

Not to be distinguished from Aru-Island birds in the collection. A single example sent by Mr. Broadbent.

20. Arses aruensis, *Sharpe, Notes Leyden Mus.* i. p. 21, *et Cat. B.* iv. p. 410.—Arses enado, *Ramsay, l. c.* p. 269.

A pair in Mr. Broadbent's collection. The male seems to have even less black on the chin; and the female is rather brighter rufous and not so dark brown on the back. The bird from S.E. New Guinea may yet prove to be a distinct species from that of the Aru Islands when more complete series are available for comparison.

21. Pachycephala leucogastra, *Salvad. & D'Albert. Ann. Mus. Civic. Genov.* vii. p. 822.

An adult specimen in Mr. Broadbent's collection. I have compared it with the type, kindly lent to me by Count Salvadori.

22. Cinclosoma ajax.—Eupetes ajax, *Temm. Pl. Col.* ii. pl. 573; *Gray, Hand-l. B.* i. p. 267, no. 3913.—E. Goldiei, *Ramsay, l. c.* p. 303.

An adult male in Mr. Broadbent's collection, which he calls a "Mountain-Thrush." Signor D'Albertis exhibited a specimen from the Fly River at a recent meeting of the Zoological Society, and informed me that Count Salvadori had examined the series

brought by him, and had determined the bird to be the *Eupetes ajax* of Temminck. On this point the Count will be better informed than myself, as he has examined the type in the Leiden Museum, which I have not been able to do. We may therefore believe in the identity of the species now sent from South-eastern New Guinea, notwithstanding the difference in the plate of Temminck's work and the specimens now sent. The Leyden bird, however, is said to be a female; so that the differences may be merely sexual. The bird is certainly not a *Eupetes*, but is a *Cinclosoma*, and is interesting as adding one more Australian type to the avifauna of New Guinea.

The following is a description of Mr. Broadbent's specimen:—General colour above ochraceous brown, rather darker towards the lower back, rump, and upper tail-coverts; scapulars like the back; wing-coverts glossy black; quills blackish brown, externally ochraceous-brown, broader on the secondaries, the innermost of which are almost entirely ochraceous brown; two centre tail-feathers like the back; the rest of the tail black, with broad white ends to the outer feathers; lores, eyebrow, feathers below the eye, and ear-coverts glossy blue-black, forming a broad band of black, which runs from the base of the nostrils, encloses the eye, and extends down the sides of the neck; a second broad band of white extends from the base of the lower mandible, along the sides of the face, including the basal part of the ear-coverts, down the sides of the neck; cheeks, sides of throat, as well as the entire throat, fore neck, and chest glossy blue-black; sides of body from the sides of fore neck downwards clear orange-rufous, the lower flanks ochraceous brown; centre of the breast and abdomen white, separated from the orange-rufous sides of the body by a line of black, the feathers bordering the two lines of colour being externally white and internally black, the plumes of the breast where they adjoin the white of the underparts being black with white tips; thighs olive-brown; under tail-coverts mottled with white and black, the inner web being white and the outer one black; edge of wing black; under wing-coverts and axillaries white, with more or less concealed black bases; quills ashy below. Total length 9·2 inches, culmen 1, wing 3·9, tail 4, tarsus 1·35.

23. EUPETES NIGRICRISSUS, *Salvad. Ann. Mus. Civic. Genov.* ix. p. 36; *Ramsay, l. c.* p. 277.

The four specimens sent by Mr. Broadbent differ from *E. cæ-*

rulescens of North-western New Guinea exactly in the way pointed out by Count Salvadori; so that the black under tail-coverts, though a slight, seem to be a constant specific character.

24. Drymœdus Beccarii, *Salvad. Ann. Mus. Civic. Genov.* vii. p. 65; *id. P. Z. S.* 1878, p. 97.

The specimen sent in Mr. Broadbent's collection appears to belong to this species, which is one of great interest. The genus is Australian; and the present bird was described from the Arfak Mountains in N.W. New Guinea; and it was afterwards found in the Aru Islands by the 'Challenger' Expedition; so that S.E. New Guinea is an entirely new locality for the species.

25. Melanopyrrhus Robertsoni, *D'Albert.*—Mina Robertsoni, *Ann. Mus. Civic. Genov.* x. p. 12.—Eulabes orientalis, *Ramsay, l. c.* p. 279

A specimen is in Mr. Broadbent's collection; and another is in that of the Rev. Mr. Lawes. These two birds both have entirely yellow heads and necks, with a few remains of black feathers on the nape. I cannot bring myself to believe that these are of the same species as *M. anais* from North-western New Guinea, of which the Museum has three specimens collected by Mr. Wallace, and representing both adults and young. All three have well-defined black heads, with a broad yellow collar, also well defined, separating the crown from the back. The young one differs in being black below with yellow edges to the feathers, and in not having the yellow chest-patch developed. It may be surmised that *M. Robertsoni*, being so closely allied to *M. anais*, goes through somewhat similar stages of plumage, and may possibly have a black head in the immature dress. The adults, however, appear to be well characterized.

26. Reinwardtœna Reinwardti (*Temm.*); *Salvad. Ann. Mus. Civic. Genov.* ix. p. 203.

Two adult specimens in Mr. Broadbent's collection.

27. Henicophaps albifrons, *Gray*; *Salvad. Ann. Mus. Civic. Genov.* ix. p. 207.

Compared with birds from North-western New Guinea, the bill in the present specimen sent by Mr. Broadbent seems much larger. The metallic coloration also is much greener on the wing, not fiery copper as in two of Mr. Wallace's specimens in the Museum collection; a third, from N.W. New Guinea, is so

intermediate that no reliance can be placed on this colouring as a specific character.

28. PHLOGŒNAS JOBIENSIS (*Meyer*); *Gould, B. New Guinea*, part vii.—Chalcophaps margarithæ, *D'Alb. & Salvad. Ann. Mus. Civic. Genov.* vii. p. 836 (1875).—Phlogœnas margarithæ, *Salvad. op. cit.* viii. p. 495 (1878).

A somewhat immature specimen in Mr. Broadbent's collection in brown plumage, glossed with purplish violet on the sides of the neck and shoulders; the head dark grey, with a few rufous feathers remaining; the throat and chest whitish, obscured by rusty brown or greyish edges to the feathers; rest of under surface ashy brown, with obscure fulvous edges to the feathers. The specimen is not unlike Dr. Meyer's typical bird figured by Mr. Gould (*l. c.*).

29. TALEGALLUS FUSCIROSTRIS, *Salvad.*; *Sharpe, Journ. Linn. Soc.* xiii. p. 504.

The specimens sent by Mr. Broadbent and Mr. Goldie bear out the character of the dusky bill, on which Count Salvadori separated the species.

On the Classification of the Maioid Crustacea or Oxyrhyncha, with a Synopsis of the Families, Subfamilies, and Genera. By EDWARD J. MIERS, F.L.S., F.Z.S., Assistant in the Zoological Department, British Museum.

[Read March 6, 1879.]

(PLATES XII. and XIII.)

INTRODUCTORY REMARKS.

THE Oxyrhyncha, or Maioid Crabs, have been placed by nearly all carcinologists at the head of the Brachyura, on account of the high degree of concentration exhibited both in the sensory organs and nervous system. There is perhaps no one of the great divisions of the higher Crustacea more numerous in genera and species, or more interesting on account of the great variety both of form and structure exhibited in the different types, nor any in which a thorough revision of the classification is more urgently needed.

No comprehensive account of the group has appeared since the

publication, in 1834, of Milne-Edwards's first volume of the 'Histoire naturelle des Crustacés,' wherein 36 genera of this group are enumerated.

Dana, in 1852, in his account of the Crustacea of the U.S. Exploring Expedition, gives a synopsis of the then known genera, the number of which had considerably increased. Since that time, however, no further revision has appeared; but during the twenty-six years that have elapsed, a very considerable number of new forms have been made known to science, through the labours of modern carcinologists, among whom the late Dr. Stimpson and M. Alphonse Milne-Edwards must be particularly mentioned. The total number of well-established genera included in the present revision is 106; but not a few of those previously described are reduced to the rank of subgenera or are regarded as synonyma, and others, which are insufficiently known to me, are referred to parenthetically.

The Oxyrhyncha, as defined by M. Milne-Edwards, constitute as a whole a natural group; but no single character can be mentioned which will serve to distinguish them universally from the other Brachyura. Externally they are distinguished by their more or less elongated carapace (which is usually provided with a rostrum and narrows anteriorly), large epistoma, longitudinal antennules, and the position of the basal antennal joint, which in the typical Maiidæ is situated beneath the eyes. The buccal cavity is quadrate, with its anterior margin straight. The branchiæ are nine on each side, the afferent canal opens behind the pterygostomian regions in front of the anterior legs, and the efferent canal at the sides of the buccal cavity. The male genital appendages arise from the bases of the fifth ambulatory legs.

From the Oxystomata, which are closely related to the Oxyrhyncha in the narrowness of the frontal region and the concentration of the organs of sense, the latter are distinguished by the triangulate buccal cavity and the position of the afferent branchial channel; but the genus *Mesorhœa*, recently described by Stimpson, evinces a remarkable approximation on the part of the Parthenopidæ to the Oxystomatous type. From the Cyclometopa (Cancroid Crabs) the typical Maiidæ are distinguished by the longitudinal antennules and the position of the basal antennal joint; but the Parthenopidæ, again, occupy in this respect a position almost intermediate between the rest of the Oxyrhyncha and

certain Cancroidea. They may indeed be regarded as not so much true Oxyrhyncha as a group osculant between these latter and the Cancroidea and Oxystomata.

Nearly all subsequent authors have retained the Oxyrhyncha as defined by Milne-Edwards. Dr. Strahl, however, in a system of classification of the Brachyura* based mainly upon characters afforded by the structure of the basal joint (*basicerite*) of the antennæ, separates the Parthenopinæ from the Oxyrhyncha, and unites them with the Calappidæ and Matutidæ, which he removes from the other Oxystomata, and places *Oncinopus* in the vicinity of the Grapsoid genus *Hymenosoma*. His views were shortly afterwards adversely criticised by Stimpson †, who demonstrated the inconvenience of a classification founded upon the modifications of a single organ, and necessitating the dismemberment of the older natural groups, and instanced several genera which would thereby be removed from the place in the system to which their real affinities would assign them; nor do I believe Dr. Strahl's views have been adopted by any later carcinologist.

As regards the primary subdivisions of the Oxyrhyncha, the following are the principal classifications that have been proposed.

Milne-Edwards in 1834 ‡, divided the Oxyrhinques (Oxyrhyncha) into three tribes or primary groups of equal value. The first two of these, his Macropodiens and Maïens, are distinguished merely by the greater length of the ambulatory legs of the former group, in which are placed all those forms in which the first and second ambulatory legs are longer than the anterior legs and more than twice as long as the postfrontal portion of the carapace. If this distinction were rigidly applied, it would be necessary to place not only nearly-allied genera, but species of the same genus (e. g. *Doclea*) in different families. Yet it is not to be denied that the greater length of the ambulatory legs is often correlated with important modifications of the structure of the orbits and antennæ.

M.-Edwards's third group, Parthénopiens, is a perfectly natural

* Monatsber. Akad. Wissensch. Berlin, pp. 713 and 1004 (1861).

† Amer. Journ. Sci. and Arts, vol. xxv. p. 139 (1863).

‡ Histoire naturelle des Crustacés, vol. i. p. 272 (1834).

one, and has been adopted by nearly all later authors, and constitutes the fourth family, Parthenopidæ, of the present revision. The genera included in his Macropodiens are, with a few exceptions (*Latreillia*, *Egeria*, *Doclea*), included in my subfamilies Leptopodiinæ and Inachiinæ. The primary sections of his Maïens (*M. cryptophthalmes* and *M. phanérophthalmes*) although somewhat differently characterized, correspond, the former (with the exception of *Libinia*, *Lissa*, *Mithrax*, and *Chorinus*) to my family Maiidæ; the latter, except *Pericera*, *Paramicippa*, and *Stenocionops*, to the subfamily Acanthonychinæ of my family Inachidæ.

De Haan, in the fourth decade of his great work *, divides his family Majacea into five primary groups, or "genera," i. e. *Parthenope*, *Maja*, *Pisa*, *Doclea*, and *Inachus*. The first of these corresponds to my family Parthenopidæ, *Œthra* being rightly included and *Eurynome* omitted from the group. The three following are characterized only by the form of the merus joint of the outer maxillipedes (a most variable character); and the genera (or "subgenera" as they are designated by De Haan) are grouped together in each without reference to the orbital and antennal characters: consequently these groups are in no degree conterminous with those adopted in the present revision. The fifth, or *Inachus* group of De Haan, includes those genera which are characterized by the articulation of the merus joint of the outer maxillipedes with the next at its summit instead of its antero-internal angle. This is a far more natural section; yet the rigid application of this character would now necessitate the separation of genera very closely allied in other respects, as Dana has shown in the case of *Eurypodius* and *Oregonia*; and other instances might be given.

In Dana's arrangement of the Maioidea †, three legions or primary sections are established. The first (Maiinea) corresponds to the Macropodiens and Maïens of M.-Edwards, and is divided into five families; the second (Parthenopinea) corresponds to M.-Edwards's Parthénopiens; and the third (Oncininea) is established for the single genus *Oncinopus* of De Haan.

The characters of the families of the Maiinea are tabulated as follows:—

* Crustacea of the 'Fauna Japonica' of V. Siebold, p. 77 (1839).

† Amer. Journ. of Sci. and Arts (ser. 2), xi. p. 425 (1851), and U.S. Explor. Exped. xiii. Crust. i. p. 77 (1852).

Fam. i. Maiidæ. Eyes retractile into orbits.
Fam. ii. Tychidæ. Eyes retractile beneath carapace; no orbits.
Fam. iii. Eurypodidæ. Eyes retractile to sides of carapace.
Fam. iv. Leptopodidæ. Eyes not retractile. Legs very long.
Fam. v. Periceridæ. Eyes not retractile. Legs of moderate length.

With respect to this arrangement I may observe, in the first place, that the retractility or non-retractility of the eyes is scarcely a character that can be used for separating the families; for in many of the Leptopodiidæ the eyes are capable of a certain degree of mobility, and in many Periceridæ they are, as Stimpson has pointed out, completely retractile within the orbital cavity. It is somewhat remarkable that Dana did not observe the characters that are afforded by the structure of the orbital region itself, taken in conjunction with the concurrent modification of the form of the basal antennal joint, to which attention had already been drawn by Milne-Edwards, and which, I am convinced, offer far better distinctions for a natural arrangement of the various groups. Within his first family (Maiidæ) Dana includes most of the genera referred by me to the Maiidæ and Periceridæ; his second family (Tychidæ) contains but three genera, whereof the last, *Camposcia*, has but little affinity with the two preceding; the third (Eurypodidæ) also includes but three genera, all referable to my family Inachidæ; the fourth (Leptopodidæ) corresponds, with the exception of *Inachoides*, to my subfamily Leptopodiinæ. The fifth (Periceridæ) is a somewhat heterogeneous group; but the majority of the genera included in it belong to my subfamily Acanthonychinæ of the family Inachidæ.

The subfamilies of the Maiinea instituted by Dana appear to me to be unnecessarily numerous, and are for the most part founded upon characters of minor importance, *i. e.* the form of the carapace and rostrum. His minor subdivisions, indeed, are less natural than those of Milne-Edwards; but to him belongs the merit of having recognized that the Parthenopinea form a group equal in value to the remainder of the Oxyrhyncha (with the single exception of *Oncinopus*).

M. Alphonse Milne-Edwards, by whose finely illustrated memoirs our knowledge of the genera of Oxyrhyncha has been so greatly increased, has not, I believe, published any classification of the group; but in his classification of the Brachyura set forth in the introductory portion of his 'Histoire naturelle des Crustacés

fossiles'*, establishes two families, Inachoïdiens and Maïens, apparently corresponding to Dana's Maiinea and Parthenopinea.

The late Dr. Stimpson, in his Preliminary Report of the Crustacea Brachyura dredged in the Gulf Stream †, points out several errors in Dana's classification, and proposes or amends the characters of several subfamilies and families. Of these the Pericerinæ, Othoniinæ, Eurypodiidæ and Acanthonychidæ would seem to correspond respectively to my Periceridæ, Othoninæ, Inachidæ and Acanthonychinæ; but as often only a single character is mentioned by which to distinguish the groups, and no lists of the genera included are given, the limits he would have assigned to them had he lived to publish a complete system must remain uncertain. His subfamilies Leptopinæ and Collodinæ are not retained in the present classification.

It may be useful in conclusion to refer to the arrangement adopted by Dr. Claus in his lately-published Treatise on Zoology (Grundzüge der Zoologie, 3te Aufl. p. 558, 1876), as, although this author does not do more than indicate the leading generic types of the Oxyrhyncha, his views are of special interest as emanating from a carcinologist of the highest reputation. In his system the Oxyrhyncha are divided into two families—Majidæ, Parthenopidæ—corresponding to the first and second of Dana's legions; and the Majidæ are further subdivided into three subfamilies:—(1) Majinæ, in which the eyes are retractile into orbits; (2) Eurypodinæ, in which the eyes are retractile but without orbits; and (3) Leptopodiinæ, with non-retractile eyes.

In the present revision the first and second of Dana's primary groups (Maiinea, Parthenopinea) are retained. The remarkable genus *Oncinopus*, for which Dana established a section (Oncininea) equal in value to the two above mentioned, must, I believe, be included in my family Inachidæ. The abbreviated character of the basal antennal joint is not peculiar to it, but exists also in *Macrocheira*; the genus, however, exhibits a certain degradation from the Brachyura in its subdorsally raised fifth ambulatory legs. In its antennal characters, no less than in the flattened triangulate form of the carapace, it approaches the Grapsoid genus *Elamene* and its allies.

* Ann. Sci. Nat. tome xiv. Zool. p. 185 (1860).

† Bulletin of Museum of Comparative Zoology, ii. p. 109 (1870).

Within the Maiinea, a regular gradation of characters may be traced from the forms (*Leptopodia* and *Stenorhynchus*) with non-retractile and laterally projecting eyes and narrow basal* antennal joint and elongated epistoma, at one end of the series, to those (exemplified in *Pericera* and *Mithrax*) with deep circular and well-defined orbits, transverse epistoma, and greatly developed basal antennal joint, at the other; and I accordingly distinguish among the Maiinea three principal groups, founded upon the orbital and antennal characters, as will be seen in the following tabular arrangement.

Legion I. MAIINEA. (*Maiinea*, Dana; *Inachoïdiens*, A. M.-Edwards.) Basal antennal joint well developed, inserted beneath the eyes, and occupying a great part of the infraocular space.

Family I. INACHIDÆ. Eyes non-retractile, or retractile against the sides of the carapace. No defined orbits exist; but there is often a well-developed præocular or postocular spine. Basal joint of antennæ usually very slender, sometimes moderately enlarged.

Family II. MAIIDÆ. Eyes retractile within the projecting orbits, which are more or less incomplete below the eyes, or marked with open fissures in their upper or lower margins. Basal antennal joint always more or less enlarged.

Family III. PERICERIDÆ. Eyes usually retractile within the orbits, which are small, deep, and circular, never incomplete. Basal antennal joint well-developed, and usually very considerably enlarged.

As a rule, there can be no difficulty in assigning to any genus its place in one or other of the three families characterized above; yet, as the Maiidæ constitute a group intermediate between the Inachidæ and Periceridæ, there are certain genera which lie on the border line separating the Inachidæ and Maiidæ, which might be referred with almost equal justice to either family unless some artificial limit were imposed. In *Loxorhynchus*, for example, the præocular and postocular spines and basal antennal joint are largely developed, and this genus approximates closely in its orbital and antennal characters to *Pisa* and its allies among the Maiinæ; and, to take another instance, *Tyche* has its upper orbital margin as much developed as *Acanthophrys* among the Maiidæ, yet cannot be separated from its natural allies *Stenocionops* and *Stilbognathus*, which belong to the Inachidæ. Again, among the Maiinea with deflexed front, it will be shown that a regular transi-

* I use this term, in the sense commonly employed by authors, for the large joint which is apparently the first of the basal portion of the antennæ, but is in reality the second joint ("basicerite").

tion may be traced from *Micippa* with well defined orbits, to the remarkable genus *Picrocerus*, in which the true orbits are as little developed as in many Inachinæ.

In cases such as these, I believe it is often better to preserve the natural sequence of the genera, though in so doing one must slightly overstep the literal definition, than, by too strict an adherence to the definition of the group, to separate forms which in all characters save one may be nearly allied. Nature imposes no artificial limits; and not even an arbitrary distinction will in all cases avail to separate kindred forms *.

Legion II. PARTHENOPINEA. (*Parthenopinea*, Dana et auctorum). Basal antennal joint very small, and embedded with the next joint in the narrow hiatus between the front and inner suborbital angle; the infraocular space being mainly occupied by the lower wall of the orbit.

Family IV. PARTHENOPIDÆ. Characters of the section:—This group corresponds in the main with M.-Edwards's Parthénopiens; but the characters are modified to include several genera which agree with those known to Milne-Edwards in the structure of the orbits and antennæ, but differ in the carapace and anterior legs. Moreover I follow De Haan in excluding *Eurynome* (which really belongs to the Maiidæ) and including *Œthra* (which is placed by Milne-Edwards in a separate section of the Cancériens—*Cancériens cryptopodes*).

As already stated, the Parthenopinea are very distinct as a group from the rest of the Oxyrhyncha. Perhaps their nearest affinities in that direction are with *Inachus* through *Inachoides*. The triangulate form of the carapace, with its strongly marked depressions separating the different regions, is the same, and the slender basal antennal joint. In *Inachoides* the rostrum is simple, as in *Parthenope* and *Lambrus*.

In the plates that accompany this paper I have figured what may be regarded as typical examples of the principal modifications in the structure of the orbital and antennal region throughout the Oxyrhyncha, wherein may be traced the gradual

* Dana, for example, separated the *Cancroidea* into two parallel groups (Cancridæ and Eriphiidæ), characterized respectively by the presence or absence of a ridge on the endostome defining the efferent branchial channel; but in *Xanthodius*, a genus since described by Stimpson, this ridge is rudimentary, and this genus may be referred either to the vicinity of *Chlorodius* in the former, or *Ozius* in the latter group. Similar intermediate forms occur between *Actæa* and *Actæodes*, genera belonging respectively to the parallel series Xanthinæ and Chlorodiinæ in the family Cancridæ.

approximation of the Maioid to the Cancroid type through the development of the orbits and of the basal portion of the antennæ, the increase in width of the interocular portion of the carapace, the shortening of the epistome, and the obsolescence of the rostrum.

In the synoptical arrangement of the families, subfamilies, and genera which follows, I have omitted all references to the literature, as these will, it is hoped, be given on a future occasion, and the characters themselves are to be regarded as merely diagnostic. Those genera which are unknown to me from examination of specimens are distinguished by an asterisk; and it may be, as the descriptions are often short and insufficient, that I have referred one or two to a wrong position in the system. Synonyma are placed in brackets and printed in *italics*. In every case I have cited what I regard as the typical species of the genus. Many of the genera are distinguished by characters of very trivial importance; and it is impossible in any linear arrangement to express adequately their very complex affinities; but is hoped that the present arrangement, while on the whole a natural one, will serve as a practical guide to the determination and classification of the numerous types of this interesting group.

Synoptical Arrangement of the Families, Subfamilies, and Genera.

Family I. INACHIDÆ.

Eyes non-retractile, or retractile against the sides of the carapace. No defined orbits exist; but there is often a well-developed præocular and postocular spine. Basal joint of antennæ usually slender, sometimes moderately enlarged.

The carapace varies in shape, being subtriangular, or oblong-triangular, or subpyriform. Rostrum simple or bifid, sometimes very short. Anterior legs with the fingers never excavated at the tips. Ambulatory legs sometimes very long. Postabdomen of male and female 4- to 7-jointed, two or three of the joints often coalescent.

Subfamily 1. Leptopodiinæ. (See Plate XII. figs. 1, 2.) (*Macropodiens*, M.-Edwards, part.; *Leptopodidæ*, Dana, part., Stimpson.)

Eyes slender, non-retractile, and laterally projecting. Præocular and postocular spines minute or wanting. Basal antennal joint very slender throughout its length.

The carapace is subtriangular. Rostrum usually simple (bifid in *Stenorhynchus*). The merus joint of the outer maxillipedes is truncated, or elongated and rounded at its distal end, and articulated with the next joint at its summit or at its antero-external or antero-internal angle. The anterior legs have the palm cylindrical or inflated, fingers acute. Ambulatory legs slender and very long.

The genera included in this subfamily are placed at the head of the Maioidea on account of the close approximation of the eyes and antennæ and their separation from the rest of the body by the constriction of the postocular portion of the cephalothorax; the epistome is very long, and generally two or three of the post-abdominal segments coalescent.

§ *Rostrum extremely long, simple. A postocular spine. Anterior legs with the palm elongated, cylindrical. Ambulatory legs extremely long.*

LEPTOPODIA, *Leach* (*Macropus*, Latr., part.; *Pactolus*, Leach). Carapace smooth, even above. Antennæ concealed beneath the rostrum. Type *Leptopodia sagittaria* (Fabr.).

* METOPORAPHIS, *Stimpson*. Carapace uneven above. Antennæ long, flagellum exposed. Type *Metoporaphis calcarata* (Say).

§§ *Rostrum composed of two spines, or very short and simple. No postocular spine. Anterior legs with the palm shorter, inflated.*

STENORHYNCHUS, *Lamarck* (*Macropus*, Latr., part.; *Macropodia*, Leach). (Plate XII. figs. 1, 2.) Rostrum elongated, of two slender contiguous spines. Type *Stenorhynchus rostratus* (Linn.).

ACHÆUS, *Leach*. Rostrum very short, emarginate. Type *Achæus Cranchii*, Leach.

The characters derived from the form of the merus joint of the outer maxillipedes and dactyli of the ambulatory legs are subject to much variation in the exotic species.

* PODOCHELA, *Stimpson*. Rostrum simple, acute. Pterygostomian regions naked. Type *Podochela grossipes*, Stimpson.

PODONEMA, *Stimpson*. Rostrum simple, rounded, excavate beneath, and hood-shaped. Pterygostomian regions with lamelli-

form ridges defining the afferent branchial channels. Type *Podonema Riisei*, Stimpson.

Subfamily 2. INACHINÆ. (See Plate XII. figs. 3, 4.) (*Macropodiens*, M.-Edwards, part.; *Eurypodiidæ*, Stimpson.)

Eyes slender and retractile. Præocular spine usually wanting, post-ocular usually distinct. Basal antennal joint usually very slender throughout its length, not narrowing distally.

The carapace is subtriangular or subpyriform; its margin is often slightly produced over the base of the eye-peduncles. Rostrum simple, bifid, or two-spined. The merus joint of the outer maxillipedes is either truncated and articulated with the next joint at its antero-internal angle, or elongated and rounded at its distal end. The anterior legs in the male are small, or have the palm inflated and the fingers acute. The ambulatory legs are usually slender, and often very long. Postabdomen 5- to 7-jointed.

In this subfamily are included what may be considered the typical Inachidæ. The form of the merus joint of the outer maxillipedes would probably afford excellent sectional characters; but as many of the genera are unknown to me, I prefer to group them according to the form of the rostrum.

§ *Rostrum very short, emarginate.*

* *Basal antennal joint reaching to front.*

EUCINETOPS, *Stimpson.* Carapace suboblong. Rostrum short, bifid, slightly deflexed. Eyes extremely long and mobile. Outer maxillipedes with the merus joint short, truncated at distal end. Ambulatory legs of moderate length. Type *Eucinetops Lucasii*, Stimpson.

CAMPOSCIA, *Latreille.* Carapace elongated, subpyriform. Rostrum very short, emarginate. Eyes long and slender. Outer maxillipedes with the merus joint elongated, obovate, and rounded at its distal end. Ambulatory legs very long. Type *Camposcia retusa*, Latreille.

The genus *Eucinetops* in the form of the carapace, eyes, and maxillipedes has some affinity with *Micippa* and its allies; *Camposcia*, in the form of the merus joint of the outer maxillipedes, approaches *Inachus*.

The four following genera (of none of which I have seen specimens) are constituted a distinct subfamily (Collodinæ) by Stimpson, on account of the shortness of the rostrum. This character is of scarcely sufficient importance for such a purpose; and it

appears to me that these genera must certainly be arranged in the same subdivision with *Camposcia* and *Eucinetops*.

*Collodes, *Stimpson*. Carapace subtriangular. Rostrum bifid, with the spines approximated. Merus joint of outer maxillipedes produced internally. Eyes of moderate length. Ambulatory legs all subprehensile, tarsi slender. Type *Collodes granosus*, Stimpson.

*Arachnopsis, *Stimpson*. Carapace narrow, suboblong. Rostrum bifid. Eyes long. Merus joint of the outer maxillipedes broader than long. Ambulatory legs filiform, tarsi straight. Type *Arachnopsis filipes*, Stimpson.

*Batrachonotus, *Stimpson*. Carapace subtriangular. Rostrum emarginate. Merus joint of the outer maxillipedes broad. Ambulatory legs of the first pair extremely long, those of the posterior pairs very short. Type *Batrachonotus fragosus*, Stimpson.

*Euprognatha, *Stimpson*. Carapace subpyriform. Rostrum apparently trifid (the median lobe being the interantennulary spine). A præocular spine. Eye large, peduncle short. Merus joint of the outer maxillipedes somewhat L-shaped. Type *Euprognatha rastellifera*, Stimpson.

Achæopsis, *Stimpson*. Carapace triangular, with the regions well defined. Rostrum short, bifid; postocular spine small; a præocular spine present. Outer maxillipedes with the merus joint elongated. Ambulatory legs slender; three last pairs with the dactyli falciform. Type *Achæopsis spinulosus*, Stimpson.

Inachus, *Fabr*. Carapace triangular, with the regions well defined. Rostrum very short, bifid; no præocular spine; postocular spine large. Outer maxillipedes with the merus joint elongated. Ambulatory legs elongated, with the terminal joints usually straight. Type *Inachus dorsettensis* (Pennant).

** *Basal antennal joint very short, not reaching to front.*

Oncinopus, *De Haan*. Carapace elongate-triangular. Front emarginate. Basal antennal joint very short, the next longer. Merus joint of outer maxillipedes elongated and articulated with the next at its summit. Ambulatory legs slender, the penultimate joints of the first and second pairs more or less dilated and

compressed, the fifth somewhat raised upon the dorsal surface. Type *Oncinopus aranea*, De Haan.

This curious genus in the form of the basal antennal joint comes nearest *Macrocheira*, and also has some affinity with the Grapsoid genus *Elamene* and its allies. In the subdorsally elevated fifth ambulatory legs it approaches the Maioid Anomura.

§§ *Rostrum simple.*

*INACHOIDES, *Milne-Edwards* (*Xiphus*, Eydoux & Souleyet). Carapace triangular, with the regions well defined. No præocular spine. Postocular well developed. Anterior legs with the palm inflated. Ambulatory legs very slender, with the dactyli straight. Type *Inachoides microrhynchus*, M.-Edw. & Lucas.

§§§ *Rostrum long, two-spined.*

* *Spines of rostrum contiguous with one another.*

EURYPODIUS, *Guérin-Méneville.* Spines of rostrum rather stout, narrowing to distal extremity. Ambulatory legs very long, with the penultimate joint dilated and compressed. Type *Eurypodius Latreillei*, Guérin.

OREGONIA, *Dana.* (Plate XII. figs. 3, 4.) Carapace flattened, not spinose. Spines of rostrum very slender. Ambulatory legs of moderate length, very slender, with the penultimate joint similar to the preceding, not dilated and compressed. Type *Oregonia gracilis*, Dana.

PLEISTACANTHA, *Miers.* Carapace convex, spinose. Spines of rostrum long, divergent at their tips. Anterior legs in male elongated. Ambulatory legs very slender and very long, penultimate joint not dilated and compressed. Type *Pleistacantha sancti-johannis*, Miers.

** *Spines of rostrum divergent.*

1. *Third joint of outer maxillipedes not emarginate at its distal end.*

HALIMUS, *Latreille.* Carapace subtriangular, with lateral marginal spines. Three spines above the eye. Merus joint of the outer maxillipedes somewhat auriculated and produced at its antero-external angle. Anterior legs in male enlarged, palm slightly compressed. Ambulatory legs with the penultimate

joint more or less flattened, and dilated toward its distal end. Type *Halimus auritus*, Latreille.

This genus establishes a transition to the Maiidæ.

AMATHIA, *Roux.* Carapace subtriangular, spinose. No spines above the eye. Anterior legs of moderate size. Ambulatory legs slender and cylindrical, penultimate joint not dilated. Type *Amathia Rissoana*, Roux.

CHORINUS, *Leach.* Carapace elongated, convex, without lateral marginal spines. A prominent præocular spine. Eyes very small. Merus joint of the outer maxillipedes not auriculated. Anterior legs in the male greatly elongated. Ambulatory legs of the first pair much elongated, of the last three pairs short. Type *Chorinus heros* (Herbst).

MACROCHEIRA, *De Haan.* Carapace triangular. Præocular spine small. Basal antennal joint very small, not reaching the front. Merus joint of the outer maxillipedes elongated, and rounded at its distal end (as in *Camposcia* and *Inachus*). Legs very long. Type *Macrocheira Kämpferi*, De Haan.

2. *Third joint of the outer maxillipedes notched at its distal end.*

ERICHOPLATUS, *A. M.-Edwards.* Carapace subtriangular. Rostrum bifid, its spines divergent. Basal joint of antennæ rather robust. Anterior legs in male long and slender. Ambulatory legs with the penultimate joint dilated and square-truncated as in *Acanthonyx.* Type *Erichoplatus Huttoni*, A. M.-Edwards.

This genus establishes the transition from the present subfamily to the Acanthonychinæ. The single species was contemporaneously described by me as *Halimus Hectori*, from an imperfect specimen.

Subfamily 3. ACANTHONYCHINÆ. (See Plate XII. figs. 5, 6.) (*Maïens phanérophthalmes*, M.-Edw., part.; *Acanthonychidæ*, Stimpson.)

Eyes small and immobile or partially retractile, and concealed beneath the prominent præocular spine. Basal antennal joint usually enlarged at base and narrowing distally. Postocular spine small or absent.

The carapace is usually more or less oblong and flattened, more rarely elongated and subcylindrical or subtriangular. Rostrum simple or bifid. The merus joint of the outer maxillipedes is truncated at its distal end, and articulated with the next joint at its antero-internal angle. The anterior legs in the male usually have the palm compressed. The ambulatory legs are of moderate length. Postabdomen 4- to 7-jointed.

Some of the genera in the first and second sections of this subfamily approach the Leptopodiinæ in the length of their epistoma, narrow interocular space, and coalescent postabdominal segments. Consequently the Acanthonychinæ are to be regarded as a series parallel with, rather than inferior to, the Leptopodiinæ in a natural arrangement.

§ *Carapace elongated, ovate-cylindrical. Rostrum elongated, emarginate or bifurcated. Præocular minute, or wanting. Eyes immobile. Last two pairs of legs very short.*

This section would appear to correspond with Stimpson's subfamily Anomalopinæ.

XENOCARCINUS, *White* (*Huenioides*, A. Milne-Edwards). (Plate XII. fig. 5.) Carapace ovate-cylindrical. Præocular spine wanting. Antennæ concealed beneath the rostrum. Type *Xenocarcinus tuberculatus*, White.

*ANOMALOTHIR (*Anomalopus*, Stimpson, nom. præoc.). Carapace almost subcylindrical. Præocular minute. Antennæ visible from above. Type *Anomalothir furcillatus* (Stimpson).

§§ *Carapace in the male subtriangular. Rostrum simple, acute. Ambulatory legs regularly decreasing in length.*

* *Eyes immobile. Sexes (where known) dissimilar.*

*MOCOSOA, *Stimpson*. Carapace subpentagonal. Rostrum subtriangular, entire, obtuse, excavated below. Præocular? Outer maxillipedes with the merus joint short, broad, and produced at its antero-external angle. Anterior legs? Type *Mocosoa crebrepunctata*, Stimpson.

TRIGONOTHIR, *Miers*. Carapace subtriangular. Rostrum entire, obtuse, flattened below, and produced into lateral carinæ. Præocular wanting. Outer maxillipedes with merus joint not produced at its antero-external angle. Anterior legs rather small, palm compressed. Type *Trigonothir obtusirostris*, sp. n.

A single specimen, locality unknown, is in the Museum collection.

HUENIA, *De Haan*. Rostrum slender, deep, and laterally compressed, acute; præocular spine small. Sexes dissimilar (the carapace in the female being produced into large lateral lobes or expansions). Hands compressed, cristate above. Ambulatory

legs more or less dilated and compressed. Type *Huenia proteus*, De Haan.

SIMOCARCINUS, *Miers*. Rostrum as in *Huenia*, but shorter. Præocular spine wanting. Sexes dissimilar. Hands in adult male turgid, not cristate above. Ambulatory legs not compressed. Type *Simocarcinus simplex* (Dana).[1]

The type of this genus is the *Huenia simplex* of Dana: this species and his *H. brevirostrata* are obviously male and female of the same form. Specimens are in the British Museum of both sexes.

CYCLONYX, *Miers*. Rostrum laminate, flattened, very broad, and transversely oval in shape. Eyes situated in the narrow angle between the base of the rostrum and front of the carapace, the sides of which are produced into dilated wing-like expansions as in *Huenia*. Type *Cyclonyx frontalis* (White). Only known from a single female in bad condition.

** *Eyes mobile. Sexes similar.*

MENÆTHIUS, *M.-Edw*. Rostrum slender, acute. Præocular spine well developed. Carapace subtriangular. Anterior legs with the palm slightly compressed, fingers arcuate. Ambulatory legs not compressed. Type *Menæthius monoceros*, Latr.

§§§ *Carapace usually more or less oblong or orbiculate in outline. Rostrum flattened, emarginate, bifid, or two-spined. Præocular usually well developed. Eyes mobile. Basal antennal joint dilated at base, narrowing distally. Ambulatory legs of moderate length.*

* *Flagellum of antennæ concealed beneath the rostrum and not visible from above.*

*LEUCIPPE, *M.-Edwards*. Rostrum laminate, divided by a narrow median fissure. Carapace subtriangular or subpentagonal. Præocular spine wanting. Basal antennal joint not much enlarged at the base. Type *Leucippe pentagona*, M.-Edwards.

This genus marks the transition from the preceding section to the present one.

MIMULUS, *Stimpson*. Rostrum laminate, bifid. Carapace flattened, subpentagonal, with the lateral margins in both sexes produced into bilobate laminate expansions. Præocular

spine present. Basal antennal joint not much enlarged at base. Type *Mimulus foliatus*, Stimpson.

Epialtus, *M.-Edwards*. Rostrum lamellate, emarginate. Præocular spine present. Basal antennal joint considerably enlarged at base. Ambulatory legs with the penultimate joint not dilated and compressed.

Subgenus 1. Epialtus. Carapace suboblong. Second tooth of the antero-lateral margins greatly developed. Type *Epialtus bituberculatus*, M.-Edwards.

Subgenus 2. Antilibinia, *M'Leay*. Carapace suboval, smooth, or uneven. Second tooth of the antero-lateral margins small. Type *Antilibinia Smithii*, M'Leay.

I place in this subgenus the W.-American species with smooth oval carapace. M'Leay's type species is from S. Africa. In the American species (*E. dentatus*, *E. emarginatus*) the orbital margin, although not prominent, is so well defined and circular that they might almost be separated as a distinct genus, and placed near *Scyra* in the Periceridæ. *A. Smithii* externally resembles the species of *Libinia*.

*Eupleurodon, *Stimpson*. Carapace depressed and uneven; antero-lateral angles strongly prominent. Ambulatory legs strongly prehensile, penultimate joints dentigerous. Type *Eupleurodon trifurcatus*, Stimpson.

This genus seems to be in some degree intermediate between the subgenera *Epialtus* and *Antilibinia*.

** *Flagellæ of antennæ exposed and visible from above at side of rostrum (basal joint of antennæ not much enlarged at base).*

Pugettia, *Dana* (*Peltinia*, Dana). Carapace somewhat constricted behind the second lateral spine. Ambulatory legs slender, with the penultimate joint not dilated or compressed. Type *Pugettia gracilis*, Dana.

Acanthonyx, *Latreille*. (Plate XII. fig. 6.) Carapace usually suboblong, not constricted behind the second lateral spine. Ambulatory legs with the penultimate joint more or less flattened, dilated, and compressed. Type *Acanthonyx lunulatus*, Risso.

(The genus *Dehaanius* of M'Leay, Annulosa in Smith's S. Africa,

p. 57, pl. iii. fig. *a*, would seem, from the figure and the position assigned to it by its author, to have the eyes retractile within well-defined orbits, and hence to be referable to the family Maiidæ. Except as regards the orbital characters, the species figured (*Dehaanius acanthopus*) altogether resembles the S.-African *Acanthonyx dentatus*, M.-Edw. Perhaps there is some error in M'Leay's delineation of the species in question.)

Subfamily 4. Microrhynchinæ.

Eyes short and completely retractile; the postocular spine or lobe largely developed. Basal antennal joint considerably enlarged throughout its length (except in some *Docleæ*). Præocular spine short or absent.

The rostrum is simple or more or less bifurcated. Carapace more or less triangular and convex. The merus joint of the outer maxillipedes cordiform, or truncated at its distal extremity. Legs usually rather slender. Postabdomen of male and female 6- to 7-jointed.

This group is altogether intermediate in the structure of the orbital and antennal region between the Inachidæ and the Maiidæ. The genus *Loxorhynchus*, for example, closely approaches in these respects *Pisa* and its allies; but the upper orbital margin is not developed as in the genera of that section of Maiidæ. Of most of the genera I have seen no specimens.

§ *Rostrum simple. No præocular spine.*

* Microrhynchus, *Bell* (? *Salacia*, M.-Edwards & Lucas). Carapace broadly triangular. Rostrum very short. Merus joint of outer maxillipedes somewhat cordiform. Anterior legs in male small. Ambulatory legs of moderate length. Type *Microrhynchus gibbosus*, Bell.

*Apiomaia, *v. Martens* (*Pyromaia*, Stimpson). Carapace somewhat pyriform. Merus joint of outer maxillipedes with the antero-internal lobe strongly projecting. The rest nearly as in *Microrhynchus*. Type *Apiomaia cuspidata* (Stimpson).

*Esopus, *A. Milne-Edwards*. Carapace elongate-oval, convex. Front rounded at its distal end. Outer maxillipedes with the merus joint slightly produced at its antero-lateral angle. Type *Esopus crassus*, A. M.-Edwards.

§§ *Rostrum bifid or emarginate. A præocular spine usually present.*

Loxorhynchus, *Stimpson*. Rostrum slightly deflexed, bifid;

the spines coalescent at base, and then divergent. A prominent præocular and postocular spine. Basal joint of antennæ considerably enlarged. Merus joint of outer maxillipedes entire at its distal end. Ambulatory legs of moderate length. Type *Loxorhynchus grandis*, Stimpson.

*LIBIDOCLEA, *M.-Edwards*. Rostrum prominent, not deflexed and emarginate at its distal end. Merus joint of outer maxillipedes notched at its distal margin. Legs rather long. Type *Libidoclea granaria*, M.-Edw. & Lucas.

This genus is closely allied to *Libinia* in the family Periceridæ.

DOCLEA, *Leach*. Carapace orbiculate-triangular, or orbiculate. Rostrum usually very short, emarginate. No præocular spine. Basal antennal joint but moderately enlarged at base, Legs very long and slender. Type *Doclea Rissonii*, Leach.

This genus is closely allied to *Egeria*, and marks the transition to that genus of Maiidæ.

Subfamily 5. STENOCIONOPINÆ.

Eyes elongated and retractile, partly concealed by the præocular spine, which is very greatly elongated. Basal antennal joint considerably enlarged throughout its length.

The rostrum is composed of two spines. Carapace somewhat oblong and posteriorly prolonged. The articulation of the merus joint of the outer maxillipedes with the preceding joint is often very peculiar.

The enlarged basal antennal joint marks the approach of this subfamily to the Maiidæ. Were the upper orbital margin as well developed in all the genera as in *Tyche*, it would be better to constitute it a subfamily of that group.

*STENOCIONOPS, *Latreille*. Upper orbital margin behind præocular spine not developed. Posterior lobe of the carapace simple. Merus joint of outer maxillipedes greatly produced and acute at its antero-external angle, and with a notch on its inner margin for the insertion of the fourth joint. Type *Stenocionops cervicornis* (Herbst).

*STILBOGNATHUS, *v. Martens*. Facies of *Stenocionops*. Ischium joint of the outer maxillipedes with a longitudinal pit on its outer surface which is covered with bristles; merus joint convex and

shining, with a flat rounded lobe at its antero-external angle. Type *Stilbognathus erythræus*, v. Martens.

TYCHE, *Bell* (*Platyrhynchus*, Desb. & Schramm*). Upper orbital margin behind the præocular spine well developed, laterally produced, and concealing the eyes, with a deep fissure. Ischium and merus joints of outer maxillipedes flat and smooth, the third or merus joint dovetailed into the second, not produced, or with a small lobe at its antero-external angle. Type *Tyche lamellifrons*, Bell.

Family II. MAIIDÆ.

Eyes retractile within the orbits, which are distinctly defined; but often more or less incomplete below, or marked with open fissures in their upper and lower margins. Basal antennal joint always more or less enlarged.

Subfamily 1. MAIINÆ. (See Plate XII. figs. 7–10.) (*Maïens cryptophthalmes*, M.-Edwards, part.).

Carapace usually subtriangular. Rostrum well developed. Anterior legs in male enlarged; fingers not excavate at tips.

This subfamily includes most of those typical forms which group themselves around the common *Maia*, in which the carapace is usually triangular or elongate-triangular, the rostrum emarginate or two-spined, the orbits large, well defined and yet incomplete, eyes completely retractile, anterior legs with fingers acute, and ambulatory legs usually of moderate length.

Stimpson proposed to separate as a distinct subfamily (*Leptopinæ*) the group typified by *Egeria* (*Leptopus*, Latr.), on account of the broad and somewhat cordiform merus joint of the outer maxillipedes. *Egeria* could not in any case be taken as typical of the group, as in it the merus joint of the outer maxillipedes is not cordiform, but truncated at its distal end. A certain affinity undoubtedly exists between the genera in which the merus joint is cordiform, as also between those (typified by *Camposcia*) which have the merus joint elongated, often rounded at the distal end, and articulated with the next at the summit; but these characters cannot be employed as a basis for a general classification, and do

* I have not had an opportunity of consulting Dr. Schramm's work, 'Crustacés de la Guadeloupe d'après un manuscrit du docteur Desbonne, 1re partie, *Brachyura*. Basse-Terre, 8vo, 1867." In referring to it I have followed M. A. Milne-Edwards's citations.

not always harmonize with the characters derived from the structure of the orbits and antennæ.

§ *Rostrum vertically compressed and laminated, bifid, or notched at the extremity. Orbits shallow and very open above, so that the eyes, when retracted, are more or less visible from above, the eyes themselves short and thick.*

* *Ambulatory legs extremely long and slender.*

EGERIA, *Latr.* (*Leptopus*, Lamk., pt.). Carapace broadly triangular, spinose. Rostrum prominent, notched. Orbits with two wide fissures below. Basal antennal joint rather narrow. Anterior legs of male rather small. Type *Egeria longipes* (Herbst).

CHORILIBINIA, *Lockington.* Carapace triangular. Rostrum long, the spines coalescent at base and divergent at tip. Basal antennal joint moderately enlarged. Upper orbital margin very prominent. Eye-peduncles short. Type *Chorilibinia angusta*, Lockington.

** *Ambulatory legs of moderate length.*

a. *Carapace not spinose.*

*HEMUS, *A. Milne-Edwards.* Rostrum deflexed, notched at the extremity. Basal joint of antennæ enlarged; the second and third joints also dilated and visible from above, with lateral wing-like expansions. Merus joints of the ambulatory legs considerably dilated. Type *Hemus cristulipes*, A. Milne-Edwards.

HYAS, *Leach.* Rostrum bifid; the median fissure narrow. Basal joint of antennæ not much enlarged, the second joint moderately dilated, the third joint narrow. Ambulatory legs not dilated or compressed. Type *Hyas araneus* (Linn.).

CHIONŒCETES, *Kröyer* (*Peloplastus*, Gerstäcker). Rostrum notched, not deflexed. Basal joint of antennæ very narrow, second and third not dilated. Ambulatory legs in the adult with the joints somewhat compressed and flattened. Type *Chionœcetes opilio*, Kröyer.

b. *Carapace spinose.*

HERBSTIA, *Milne-Edwards* (*Rhodia*, Bell, *Micropisa*, Stimpson). Rostrum notched. Carapace broadly triangular, with the regions

well defined. Second and third joints of antennæ slender. Ambulatory legs slender, cylindrical.

Subgenus 1. Herbstia. Inferior margin of orbit without a tooth. Ambulatory legs not spinose. Type *Herbstia condyliata* (Herbst).

Subgenus 2. *Herbstiella, *Stm.* Inferior margin of orbit toothed. Merus joint of ambulatory legs spinose. Type *Herbstiella depressa*, Stm.

This genus establishes a relationship to *Mithrax*.

*Cœlocerus, *A. Milne-Edwards.* Carapace suborbiculate. Rostrum prominent, with a shallow notch at its distal end, and its lateral margins involuted. Second and third joints of antennæ slender. Legs short. Type *Cœlocerus spinosus*, A. M.-Edwards.

Is nearly allied to *Libinia*; and it may be desirable so to modify its characters as to include any species of that genus which may have the orbital margin incomplete or notched. The involution of the margins of the rostrum is of minor importance, as the same character occurs in a lesser degree in the typical species of *Libinia* (*L. emarginata*).

§§ *Rostrum composed of two more or less distinct divergent spine Orbits deep, so that the eyes, when retracted, are concealed; the eyes themselves small, the eye-peduncles slender.*

† *Orbits large, with a forward aspect, usually very incomplete below, the upper orbital margin usually prominent, with two deep fissures and long spines.*

**Flagellum of the antennæ arising within the orbital cavity.*

Maia, *Lamarck.* (Plate XII. figs. 7, 8.) Spines of rostrum divergent from their base. Carapace triangulate-oblong, the interorbital space broad. Basal joint of antennæ very much enlarged. Anterior legs in male rather slender; wrist elongated, not carinated. Type *Maia squinado* (Linn.).

***Flagellum of the antennæ arising within the orbital margin, and separated from the cavity of the orbit by a narrow process of the basal joint.*

Paramithrax, *M.-Edwards.* Carapace subtriangular. Spines of rostrum divergent from their base. Anterior margin of buccal cavity straight, or nearly so. Basal joint of antennæ very much

enlarged. Merus joint of outer maxillipedes notched at its antero-internal angle.

Subgenus 1. LEPTOMITHRAX, *Miers*. Anterior legs in male elongated, slender; hand and wrist subcylindrical; wrist not ridged, fingers meeting along their inner edges when closed. (Carapace not spinose above.) Type *Leptomithrax longimanus*, Miers.

Subgenus 2. PARAMITHRAX, *M.-Edw.* Anterior legs in the male enlarged; hand compressed, fingers with a vacant space between them when closed, wrist with two ridges, the outer usually oblique. (Carapace usually spinose above.) Type *Paramithrax Peronii*, M.-Edw.

As regards external form, every gradation appears to be established between the typical *Paramithrax* and *Acanthophrys*, in which the carapace and legs are more or less spinose, the upper orbital margin produced above; but the spine at the antero-external angle of the basal joint of the antennæ projects laterally instead of forward, as in that genus; and the form of the merus joint of the outer maxillipedes is different.

(The genus **Phycodes*, established by A. Milne-Edwards on a species, *P. antennarius*, from St. Vincent, has, I believe, never been figured, but should perhaps be referred to the vicinity of *Paramithrax*. The carapace is pyriform. Spines of rostrum short, acute. Orbits large, ill-defined, emarginate above; eyes partially retractile; postocular spine large. Basal antennal joint long, enlarging distally, ending in two spines, of which the outer is very prominent; flagellum inserted outside rostrum. Third joint of outer maxillipedes much larger on its outer than its inner side. Ambulatory legs long; dactyli curved. There appears to be some inconsistency in the generic and specific descriptions of the frontal and orbital region.)

*OPLOPISA, *A. Milne-Edwards*. Carapace pyriform. Spines of rostrum straight, divergent. Anterior margin of buccal cavity much more prominent on the sides than in the median portion. Merus joint of outer maxillipedes much dilated at its antero-external angle. Ambulatory legs short, and regularly spinose. Type *Oplopisa spinipes*, A. Milne-Edwards.

ACANTHOPHRYS, *A. Milne-Edwards*. Carapace subtriangular. Spines of rostrum divergent. Upper orbital margin prominent. Supraocular spine produced above the eye. Basal antennal joint

with a spine at its antero-external angle, which projects forward. Anterior margin of buccal cavity straight, or nearly so. Merus joint of outer maxillipedes dilated at its distal margin, rounded and entire, without any notch for the insertion of the next joint. Type *Acanthophrys cristimanus*, A. Milne-Edwards.

I propose to restrict this genus to species characterized by the *entire* merus joint of the outer maxillipedes, as there appears to be no other certain distinction between it and *Paramithrax*, and accordingly cite *A. cristimanus* as the type, because (if the figure be correct) it presents this peculiarity. Two species of the genus are in the British-Museum collection.

†† *Orbits small, with a lateral aspect; orbital margin not prominent, with a hiatus above and below (rarely in* Pisa *there are two hiatus above).*

Pisa, *Leach.* (Plate XII. figs. 9, 10.) Carapace triangular, rounded behind. Præocular spine usually large. Spines of rostrum long, parallel, or in contact, to near their extremities. Epistome transverse, rather narrow. Basal joint of antennæ much enlarged, and terminating at its distal extremity in one or two spines or tubercles.

Subgenus 1. Pisa, *Leach* (*Blastus*, Leach). Anterior legs in the male with the palm dilated; fingers curved, and meeting only at the ends. Carapace ovate-triangular. Type *Pisa tetraodon* (Pennant).

Subgenus 2. Arctopsis, *Lamarck.* Carapace subtriangular. Anterior legs in the male with the palms elongated and rather slender; fingers straight, and meeting along their inner edges. Type *Arctopsis lanata*, Lamarck.

*Pisoides, *Milne-Edwards & Lucas.* Carapace subtriangular. Spines of rostrum short, subparallel. No præocular spine. Epistome very narrow, nearly linear. Basal antennal joint with a tubercle at its distal end. Type *Pisoides Edwardsii* (Bell).

Notolopas, *Stimpson.* Carapace with the back flattened, and bounded posteriorly by a broad concave lamella. Rostrum with the spines divaricate. A præocular spine. Basal joint of antennæ with a lobe at its distal end. Type *Notolopas lamellatus*, Stimpson.

Hyastenus, *White* (*Lahaina*, Dana). Carapace triangular, rounded behind. Spines of rostrum long, straight, divergent from their base. Præocular spine small or obsolete. Orbits small, with a hiatus above and one below. Basal joint of antennæ not much enlarged. First ambulatory legs greatly elongated.

Subgenus 1. Hyastenus. Carapace smooth and even above, with none or with few long spines. Basal joint of antennæ without a spine at its distal end. Anterior legs in male small and slender. Type *Hyastenus Sebæ*, White.

Subgenus 2. Chorilia, *Dana*. Carapace uneven and tubercular above. Basal joint of antennæ usually with a spine at its distal end. Anterior legs in male usually enlarged, with the palm compressed. Type *Chorilia longipes*, Dana.

(The genus *Lahaina*, Dana, is intermediate between *Hyastenus* and *Chorilia*. In the form of the carapace and rostrum and anterior legs it resembles the first; in the presence of a præocular spine, and the existence of a spine on the basal joint of the antennæ, the second. Nevertheless, as the subgenera *Hyastenus* and *Chorilia* represent two types of the genus differing much in external appearance, it seems better to retain them as distinct.)

Naxia, *M.-Edw.* (*Naxioides*, A. Milne-Edwards; *Podopisa*, Hilgendorf). Carapace subtriangular. Spines of rostrum parallel, and bearing near their extremities an accessory spinule. Præocular spine usually present. Orbits as in *Hyastenus**. Basal joint of antennæ longer than broad; its antero-external angle tuberculiform. First ambulatory legs very long. Type *Naxia serpulifera*, M.-Edwards.

Scarcely distinct, perhaps, as a genus, from *Hyastenus*.

Micippoides, *A. Milne-Edwards*. Carapace subtriangular. Spines of rostrum rather short, deflexed, acute. No præocular spine. Basal joint of antennæ enlarged, without spine or tubercle at its distal end. Anterior legs in male with the palm dilated. Ambulatory legs of moderate length. Type *Micippoides angustifrons*, A. M.-Edwards.

Marks a transition to *Prionorhynchus* among the Periceridæ.

* In young specimens of *N. serpulifera* the fissures of the orbits are wider, and constitute a veritable hiatus. It appears, therefore, necessary to unite *Naxioides*, A. M.-Edwards, with this genus, as it is only distinguished by the absence of a præocular spine, a character which by itself cannot be considered of generic importance.

Eurynome, *Leach.* Carapace subtriangular, tuberculated, and spinose. Spines of rostrum laminate at base, acute at ends, slightly divergent. No præocular spine. Basal antennal joint enlarged at base, longitudinally sulcated, without a spine at its distal end. Anterior legs in male elongated, much longer than the ambulatory legs, which are all of moderate length. Type *Eurynome aspera* (Pennant).

This genus has been placed by Milne-Edwards and other authors in the Parthenopidæ; but in all structural characters it is obviously allied to *Pisa* and *Hyastenus*.

Pelia, *Bell.* Carapace subpyriform. Rostrum with the spines united at base, afterwards divergent. No præocular spine. Basal antennal joint elongated; its distal half visible from above at the side of the rostrum. Legs all of moderate length. Type *Pelia pulchella*, Bell.

Subfamily 2. Schizophrysinæ.

Carapace very broadly triangular, or oval, or nearly circular. Rostrum very short or obsolete. Anterior legs in male small, slender; the fingers usually excavated at the tips.

This subfamily establishes the transition of the Maiidæ to the subfamily Mithracinæ in the Periceridæ, and includes those Maioids in which the rostrum is reduced, until in *Cyclax* its spines are represented only by two small tubercles, the orbits often nearly complete, or marked with very narrow fissures, the carapace broadly triangular or nearly circular, the epistome short, the basal antennal joint very largely developed, and the anterior legs with the fingers more or less excavated.

§ *Anterior legs with the fingers acute at the tips.*

*Temnonotus, *A. Milne-Edwards.* Carapace ovate-elliptical, convex and tuberculated above, with a horseshoe-shaped pit on the dorsal surface. A præocular spine present. Spines of rostrum simple, well developed. Orbital fissures narrow; eyes short, thick. Basal joint of antennæ much enlarged. Type *Temnonotus granulosus*, A. M.-Edwards.

Only females of this genus are known; and it is possible that in adult males the fingers may be excavated as in other genera of the same group.

§§ *Anterior legs with the fingers excavated at the tips.*

SCHIZOPHRYS, *White* (*Dione*, De Haan, nom. præoc.). Carapace orbiculate-triangular or rarely elongated. Spines of rostrum distinct, with one or more accessory spines upon their outer margins. Orbits large. Basal joint of antennæ rather slender, with two spines at its distal end. Type *Schizophrys aspera* (Milne-Edwards).

The fingers are acute and not excavated in *S. dama* (Herbst), a species which differs from others of the genus in its more elongated form, and approaches the Maiidæ.

CYCLAX, *Dana*. Carapace orbiculate or oblong-orbiculate. Spines of rostrum simple, very short or rudimentary. Orbits large. Basal joint of antennæ usually much enlarged.

The accessory spines of the rostrum of *Schizophrys* constitute the only positive distinction (although an arbitrary one) that can be employed to separate the species of that genus from *Cyclax* and *Nemausa*.

Subgenus 1. CYCLAX, *Dana*. Spines of rostrum longer. Eye-peduncles longer. Basal joint of antennæ slenderer, with two spines at its distal end. Type *Cyclax Perryi*, Dana.

Subgenus 2. CYCLOMAIA, *Stimpson*. Spines of rostrum rudimentary. Eyes large. Basal joint of antennæ very broad, with three spines at its distal end. Type *Cyclomaia suborbicularis*, Stimpson.

(The genus **Pleurophricus* of Alphonse Milne-Edwards, founded upon a species, *P. cristatipes*, from Australia (Journ. Mus. Godeffroy, iv. p. 84, pl. xii. fig. 6, 1873), is placed by that distinguished carcinologist among the Oxyostomata; but judging from the description and figure of the third maxillipede, I should certainly suppose its true position to be in this subfamily of the Oxyrhyncha. It is distinguished from *Cyclax*, *Schizophrys*, and *Temnonotus* by the anterior legs, which are short and somewhat enlarged, and by the front, which is quadridentate.)

Subfamily 3. MICIPPINÆ. (See Plate XIII. figs. 1, 2, 3.)

Carapace suboblong. Rostrum vertically, or nearly vertically, deflexed, usually broad, lamellate. Anterior legs with the fingers acute at tips. Basal antennal joint very much enlarged. Eye-peduncles very long, geniculated, and laterally projecting.

Notwithstanding the great dissimilarity of *Micippa* and *Picrocerus*, which stand at opposite extremes of the series, a regular gradation may be traced between the genera of this group. In *Picrocerus* the broad and lamellate rostrum of *Micippa* and *Paramicippa* is reduced to a single vertically deflexed spine, the præocular spines are enormously developed, and constitute the apparent rostrum; the anterior part only of the upper wall of the orbit is developed, the posterior part, which is complete in *Micippa*, being represented only by two or three spines: hence the carapace behind the eyes appears constricted; the basal antennal joint, moreover, is narrower and elongated. *Criocarcinus* occupies an intermediate position between *Micippa* and *Picrocerus*.

§ *Orbits very incomplete, the anterior portion partially surrounding the eye-peduncle, and usually of the form of a tube open below, the posterior portion often represented only by one or two spines.*

Criocarcinus, *M.-Edwards*. (Plate XIII. fig. 3.) Orbits tubular, open below; præocular spines small. Rostrum lamellate at base, and terminating in two divergent spines. Legs of moderate length. Type *Criocarcinus superciliosus* (Herbst).

Picrocerus, *Alphonse Milne-Edwards*. Orbits tubular, open below. Rostrum rudimentary, composed of a single vertically deflexed spine. Præocular spines enormously developed, horizontal, and slightly divergent; constituting the apparent rostrum. Legs long and slender. Type *Picrocerus armatus*, A. M.-Edwards.

Pseudomicippe, *Heller*. Orbits not tubular, covering the eye-peduncles above, not defined below, with a hiatus above. Rostrum obliquely deflexed, composed of two divergent spines. Præocular spines small. Legs of moderate length. Type *Pseudomicippe nodosa*, Heller.

Establishing the transition to *Tyche* and its allies.

§§ *Orbits of a narrow oval form, well defined; basal antennal joint much enlarged.*

Micippa, *Leach*. (Plate XIII. figs. 1, 2.) Rostrum nearly vertically deflexed. Anterior legs in male with the palm elongated and rather slender; fingers meeting along their inner edges when closed. Type *Micippa cristata* (Linn.).

Paramicippa, *M.-Edwards.* Rostrum less vertically deflexed. Anterior legs in the male with the palm enlarged, shorter, smooth; fingers, when closed, meeting only at the ends. Type *Paramicippa platipes* (Rüppell).

The eyes are, I believe, retractile in both genera; and the characters derived from the orbital and antennal region are subject to variation.

Family III. PERICERIDÆ. (*Maïens cryptophthalmes*, M.-Edwards, part.)

Eyes retractile within the small circular and well-defined orbits, which are never incomplete as in the Maiidæ. Basal antennal joint well developed, and constituting the greater portion of the inferior wall of the orbit; this joint is usually very considerably enlarged.

Subfamily 1. Pericerinæ. (See Plate XIII. figs. 4, 5.) (*Pericerinæ*, Stimpson.)

Carapace more or less subtriangular in shape. Rostrum well developed. Second joint of antennæ not dilated. Anterior legs with the fingers acute at the tips.

In this subfamily are included those which may be regarded as the typical genera of this family, in which the spines of the rostrum are well developed, and often in contact with one another. The interorbital space is very broad, and the orbits tubular; the basal joint of the antennæ very much enlarged, the epistoma short, the legs of moderate length, and the fingers acute at tips. One or two of the genera (*Scyra*, *Sphenocarcinus*), in which the basal antennal joint is least developed, are related to the Epialtinæ.

§ *Rostrum emarginate at apex only.*

Libinia, *Leach.* Carapace orbiculate-triangular, convex, spinose. Præocular spine distinct. Basal joint of antennæ moderately enlarged. Legs of moderate length. Type *Libinia emarginata*, Leach.

Prionorhynchus, *Jacquinot & Lucas.* Carapace subtriangular. Præocular spine absent. Rostrum broad, lamellate, deflexed and emarginate at its distal end. Basal joint of antennæ greatly enlarged. Type *Prionorhynchus Edwardsii*, Jacq. & Lucas.

§§ *Rostrum composed of two distinct spines.*

* *Basal joint of antennæ without a spine at its distal extremity.*

SCYRA, *Dana.* Præocular spine present. Spines of rostrum lamellate at base, acute at distal end. Basal joint of antennæ narrow. Anterior legs rather long, palm carinated. Ambulatory legs not compressed. Type *Scyra acutifrons*, Dana.

*PYRIA, *Dana.* Præocular spine absent. Spines of rostrum lamellate. Anterior legs slender. Ambulatory legs much compressed. Type *Pyria pubescens*, Dana.

Nothing is said respecting the orbits and basal antennal joint; if the orbits are incomplete, this genus would probably be placed near *Chionœcetes.*

LISSA, *Leach.* Carapace very convex. Præocular spine present. Spines of rostrum flattened, contiguous, and produced at their extremities into a lateral lobe. Basal joint of antennæ much enlarged. Anterior legs with the palm compressed but not carinated. Ambulatory legs of moderate length. Type *Lissa chiragra* (Fabr.).

*RACHINIA, *A. Milne-Edwards.* Præocular spine present. Spines of rostrum slender and divergent. Anterior legs with the palm compressed but not carinated. Ambulatory legs very slender. Type *Rachinia gracilipes*, A. Milne-Edwards.

The description of this genus is taken from the figure in the 'Mission Scient. Mexique, Crustacés Podophthalmaires,' pl. xviii. fig. 1. The species is noticed, but not described, in a footnote on p. 86. Of this fine work, which contains descriptions and figures of many new genera and species, only a portion, referring to the Crustacea Xiphosura and a part of the Oxyrhyncha, has yet appeared (5me partie, livraisons 1–3. Paris, 4to, 1873 & 1875).

*LEPTOPISA, *Stimpson.* Carapace narrow, with perpendicular sides. Spines of rostrum very slender and contiguous. Anterior legs in the male large; fingers widely gaping. Ambulatory legs long and slender. Type *Leptopisa setirostris*, Stimpson.

*SPHENOCARCINUS, *A. M.-Edwards.* Carapace triangular. Rostrum elongated, its spines contiguous to within a very short distance of their extremities, which are acute. Anterior legs small. Ambulatory legs of moderate length. Type *Sphenocarcinus corrosus*, A. M.-Edwards.

This genus is only known to me from M. A. Milne-Edwards's figure in the 'Mission Scientif. Mexique' (pl. xvii. fig. 5), from which the diagnosis is taken. Its nearest ally among the Pericerinæ seems to be *Scyra*, Dana. If the orbits are incomplete, it would probably be placed among the Epialtinæ. It agrees, however, with most of the Periceridæ in having a short epistome.

** *Basal joint of antennæ often very much enlarged, with one or more spines at its distal extremity.*

† *Carapace narrow and elongated, nearly vertically deflexed in front of gastric region.*

Cyphocarcinus, *A. M.-Edwards.* Spines of rostrum slender and divergent. Spine of basal antennal joint small. Type *Cyphocarcinus minutus*, A. M.-Edwards.

†† *Carapace subtriangular, not deflexed in front.*

1. *Spine at antero-external angle of antennal joint very short, and not visible from above.*

Tiarinia, *Dana.* Carapace tuberculated, without a distinct series of lateral spines. Spines of rostrum very slender and contiguous. Interorbital space broad. Anterior legs in male with the palm short; fingers gaping. Ambulatory legs nodose or spinose. Type *Tiarinia cornigera* (Latreillé).

Tylocarcinus, *Miers* (*τύλος, a knob*). Carapace tuberculated, without lateral spines. Spines of rostrum slender, divergent. Interorbital space narrow. Basal antennal joint not much enlarged. Anterior legs in male with the fingers nearly meeting when closed. Ambulatory legs spinose or nodose. Type *Tylocarcinus styx* (Herbst).

Pericera, *Latreille.* (Plate XIII. figs. 4, 5.) Carapace with a series of lateral spines. Spines of rostrum long and divergent. Interorbital space broad. Basal joint of antennæ very much enlarged, with two small distant spines at its distal end. Anterior legs long, palm slender and elongated, fingers not gaping. Ambulatory legs smooth. Type *Pericera cornuta*, Latreille.

2. *Spine at antero-external angle of basal antennal joint very long, and visible from above.*

Microphrys, *Milne-Edwards* (*Milnia*, Stimpson; *Perinea*,

Dana; *Fisheria*, Lockington). Carapace broadly triangular. Spines of rostrum slender and more or less divergent. Branchial spine small. Orbits not tubular. Anterior legs in male enlarged; fingers arcuate, and meeting only at the tips. Antennæ visible from above at sides of rostrum. Type *Microphrys bicornuta* (Latreille).

(The genus *Omalacantha* of Hale Streets, of which I have seen no specimen, is very closely allied to this genus, and ought perhaps to be united with it, as M. A. Milne-Edwards has pointed out. It is, however, stated by its author to be sufficiently distinguished by the flattened club-shaped joints of the antennæ; and I prefer, for the present, to regard it as distinct. In the genus *Perinea*, Dana, which establishes the transition from *Microphrys* to the next genus, the carapace is convex and the rostrum very short.)

MACROCŒLOMA, *Miers*. Carapace very convex. Branchial spine very large. Spines of rostrum parallel, or nearly so. Orbits tubular and laterally projecting; interorbital space very broad. Anterior legs in male with the palm elongated, and fingers meeting, or nearly meeting, when closed. Type *Macrocœloma trispinosa* (Latreille).

This genus is proposed for that section of the old genus *Pericera* in which is included *P. trispinosa* and its allies.

*ANAPTYCHUS, *Stimpson* (*Ala*, Lockington). Carapace broadly triangulate, with the lateral margins laminated, produced over the bases of the ambulatory legs, and regularly dentated. Spines of rostrum short. Anterior legs in male rather slender; fingers nearly meeting throughout when closed. Type *Anaptychus cornutus*, Stimpson.

Subfamily 2. OTHONIINÆ. (See Plate XIII. fig. 6.) (*Othoninæ*, Dana, Stimpson.)

Carapace suboblong; interorbital space very broad. Rostrum almost obsolete. Second joint of antennæ enlarged. Anterior legs with the fingers slightly excavated at the tips.

This subfamily is restricted to the single genus

OTHONIA, *Bell* (*Pitho*, Bell). (Plate XIII. fig. 6.) Carapace with the margins regularly dentated. Type *Othonia sexdentata*, Bell.

Subfamily 3. MITHRACINÆ. (See Plate XIII. figs. 7, 8.)
(*Mithracinæ*, Stimpson.)

Carapace broadly triangular, sometimes transverse, with the sides slightly arcuate; interorbital space narrow. Rostrum short or obsolete. Second joint of antennæ not dilated. Anterior legs with the fingers excavated at the tips.

In this subfamily are included those Periceridæ which most nearly approach the Cancroids of the subfamily Chlorodiinæ in the form of the carapace, the obsolescence of the rostral spines, the small and completely defined orbits (which do not project laterally as in the Pericerinæ), the extremely short epistoma, and the form and development of the anterior and ambulatory legs. *Mithraculus*, which stands at the end of the series, is indeed hardly to be distinguished in external form from the Cancroid *Phymodius* or *Chlorodius*, from which, however, it is in reality separated by the position and great development of the basal antennal joint. *Nemausa*, on the other hand, marks the transition to the Maiidæ.

NEMAUSA, *Alphonse Milne-Edwards*. Carapace longer than broad; spines of rostrum well developed. Basal joint of antennæ with a long spine at its distal end. Anterior legs in male not much enlarged; palm slender. Ambulatory legs not compressed. Type *Nemausa spinipes* (Bell).

This genus presents affinities with *Microphrys*, and also with *Herbstia* and *Schizophrys* among the Maiidæ.

PARATHOË, *Miers*. Carapace triangular, rounded behind. Front very small and narrow, truncated or notched. Basal antennal joint narrow as in *Scyra*, longer than broad, and without any spine at its distal end. Anterior legs with the palm dilated, and fingers arcuate, meeting at the tips. Ambulatory legs not dilated, and compressed. Type *Parathoë rotundata*, Miers.

Its habitats (the Gulf of Suez and Fiji Islands) are of great interest, as the subfamily is almost exclusively American. The examples before me have nearly the aspect of *Thoë*; hence the generic name.

(The genus *Paramaya* of De Haan was founded upon a species which he subsequently referred (rightly I believe) to *Maia*. The name may, however, have to be retained for the *Paramaya Dehaani* of White, referred to in his 'List of Crustacea in the British Museum,' p. 7 (1847). This species is founded upon a single female specimen, bleached and probably immature, which closely resembles *Mithrax*, but differs from the species of that genus in

there being no tubercles or spines on the lateral margins of the carapace and very obscurely marked tubercles on the branchial regions. The orbital margins, also, are smooth. The much dilated basal antennal joint has a single spine at its extero-distal angle; the legs are smooth.)

THOË, *Bell* (*Platypes*, Lockington). Carapace triangular, narrowed anteriorly. Rostrum very short, its spines reduced to tubercles. Basal antennal joint with a very short spine at its distal end. Anterior legs in male enlarged, palms short, dilated, fingers meeting only at tips. Ambulatory legs compressed and dilated. Type *Thoë erosa*, Bell.

MITHRAX, *Leach*. (Plate XIII. figs. 7, 8.) Carapace broadly triangular, usually transverse. Spines of rostrum short or obsolete. Basal antennal joint dilated, with short spines at its distal end. Anterior legs in male usually enlarged. Ambulatory legs not dilated and compressed.

Subgenus MITHRAX, *Leach* (*Teleophrys*, Stimpson). Carapace with the branchial regions not sulcated, sides usually spinose.

Subgenus MITHRACULUS, *White*. Carapace depressed, with shallow smooth interspaces or sulci between the tubercles on the branchial regions, antero-lateral margins tuberculate (anterior legs greatly enlarged). Type *Mithraculus sculptus* (Lamarck).

Scarcely distinct even as a subgenus from *Mithrax*, although of very different external aspect; the characters of the orbital and antennal region are not constant. *Teleophrys* of Stimpson marks the transition from *Mithrax* to *Mithraculus*.

Family IV. PARTHENOPIDÆ. (*Parthénopiens and Cancériens cryptopodes*, M.-Edwards).

Eyes usually retractile within the small circular and well-defined orbits; the inferior wall of the orbit is continued to within a very short distance of the front. The antennæ are very slender, the basal joint does not, as in the Periceridæ, constitute a great part of the interior orbital margin, but is very small, and usually does not reach to the front, and with the next joint occupies the narrow hiatus intervening between the front and inner orbital angle.

The structural relationship of this family with the Oxystomata, best evidenced in the genus *Mesorhœa*, has been already adverted to; and there are resemblances also in external characters, such as the lateral extension of the carapace over the ambulatory legs

in *Cryptopodia*, and the form of the anterior legs in certain forms (e. g. *Œthra*), in which they are capable of being closely applied to the body. On the other hand, the structure of the orbits and position of the basilar portion of the antennæ very nearly resembles that of certain Cancroid genera, as *Pilumnus* and *Trapezia*. The Parthenopidæ are related, as already stated, with the typical Oxyrhyncha through *Inachoides* and *Inachus*.

Subfamily 1. PARTHENOPINÆ. (See Plate XIII. figs. 9, 10, 11.)

Carapace equilaterally or transversely triangular or elliptical. Rostrum simple. A strongly marked depression separating the branchial from the cardiac and gastric regions. Anterior legs greatly developed, with the palm trigonous, fingers acute.

§ *Carapace not laterally expanded.*

LAMBRUS, *Leach*. (Plate XIII. fig. 9.) Carapace equilaterally triangular, with the regions convex, tuberculate. Basal antennal joint short and not reaching to the front, the inner orbital hiatus usually occupied by the second joint, which is longer than or as long as the first. Anterior legs with a tuberculated or spinose crest along the upper margin of the palm. Anterior legs usually very long. Ambulatory legs very short, smooth or minutely spinose. Type *Lambrus longimanus* (Linn.).

PARTHENOPE, *Fabricius*. Carapace equilaterally triangular. Basal antennal joint longer than the second, but not reaching the inner orbital hiatus. Anterior legs rather compressed, tuberculated, but not cristated. Ambulatory legs longer, with long spines. Type *Parthenope horrida* (Linn.).

Scarcely distinct as a genus; but it appears better to retain it as a designation for the single species *P. horrida*, than to unite it with *Lambrus*, when the rule of priority would compel the adoption of the generic term *Parthenope* for all the numerous species of the former genus, which have been universally designated as species of *Lambrus*.

* SOLENOLAMBRUS, *Stimpson*. Carapace pentagonal, smooth, convex, with the margins acute. Rostrum short and blunt, or faintly tridentate. Basal joint of antennæ about as long as the second. Pterygostomian regions ridged as in *Heterocrypta*. Anterior legs nearly as in *Lambrus*. Ambulatory legs slender, compressed. Type *Solenolambrus typicus*, Stimpson.

* Mesorhœa, *Stimpson*. Resembles *Solenolambrus* in the carapace, legs, pterygostomian and hepatic channels; but the efferent branchial channels meet in the middle of the endostome or buccal cavity, which has a triangular projection and a deep notch in its vertical laminiform wall. The third joint of the outer maxillipedes is produced forward at its internal angle and conceals the palpus. Type *Mesorhœa sexspinosa*, Stimpson.

This remarkable genus indicates an approach on the part of the Maioidea to the Oxystomatous crabs, as has already been stated.

§§ *Carapace more or less laterally expanded.*

Cryptopodia, *Milne-Edwards*. Carapace transversely triangular, with the lateral margins greatly produced, and concealing the ambulatory legs, the posterior margin also prolonged backward. Front very prominent. No ridges on the pterygostomian regions. Type *Cryptopodia fornicata* (Fabr.).

Heterocrypta, *Stimpson*. Carapace as in *Cryptopodia*, but without the posterior expansion. A strongly-marked ridge on the pterygostomian region, defining the afferent channel. Type *Heterocrypta granulata* (Gibbes).

Œthra, *Leach*. (Plate XIII. fig. 10.) Carapace transversely oval or elliptical, with the lateral margins produced as in *Cryptopodia*, and dentated. No posterior expansion. No ridge on the pterygostomian region. Type *Œthra scruposa* (Linn.).

This genus, although somewhat resembling *Cancer* and *Etisus* in external form, is much more nearly allied to *Cryptopodia* in the characters of the cephalothorax and antennæ, and must be arranged with that genus, as has been done by Stimpson and S. I. Smith.

(The genus *Eurynolambrus*, which is placed by MM. Milne-Edwards and Lucas and by Dana with the Parthenopidæ, and which in the triangular and expanded carapace has certainly much resemblance to *Cryptopodia*, has really far more affinity with *Cancer* in the form of the orbital and antennal region. The basal joint of the antennæ, as in that genus, is much enlarged, and excludes the flagellum from the orbital hiatus. The front is bilobate; and the anterior legs have not the trigonous form characteristic of *Cryptopodia* and its allies. The lateral expansions of the carapace are far smaller, and do not conceal the ambulatory

legs. I propose, then, to refer this genus to the Cancerinæ, where it marks the transition of that group to the Parthenopidæ.

The genus *Telmessus* of White, which was originally placed by its author among the Plagusiinæ and subsequently assigned to the Maiidæ (Voy. Samarang, Crust. p. 14) has externally some resemblance to *Anaptychus*. In the characters of the orbital and antennal regions, however, it has more affinity with the Cancroid than the Maioid crabs; and its most natural position is perhaps among the Corystoidea, where Dana placed it.)

Subfamily 2. Eumedoninæ.

Carapace usually rhomboidal or subpentagonal, with a spine at the junction of the antero-lateral and postero-lateral angles. Rostrum usually bifid or emarginate. Depressions separating the regions of the carapace obscure or non-existent. Anterior legs of moderate length, not trigonous.

§ *Carapace flat and smooth above. Ambulatory legs with all the joints greatly dilated and compressed.*

Zebrida, *White*. Spines of rostrum and lateral spines of carapace large, laminate. Basal antennal joint large and filling the orbital hiatus. Type *Zebrida Adamsii*, White.

§§ *Carapace uneven or convex. Ambulatory legs slender.*

*Eumedonus, *Milne-Edwards*. Carapace depressed. Rostrum long and emarginate at its extremity, where the spines are divergent. Anterior legs rather large. Ambulatory legs slightly compressed, with the third joint somewhat cristated. Type *Eumedonus niger*, Milne-Edwards.

Gonatonotus, *Adams and White*. Carapace uneven above. Rostrum broad, lamellate, rounded, and very slightly emarginate or entire at its distal extremity. Anterior legs of moderate size. Ambulatory legs slender, not dilated and compressed. Type *Gonatonotus pentagonus*, Adams and White.

Ceratocarcinus, *Adams and White*. Carapace tuberculated above. Rostrum composed of two slender widely separated spines. Anterior legs of moderate size. Ambulatory legs slender. Type *Ceratocarcinus longimanus*, Adams and White.

In this remarkable genus, the inner orbital hiatus is completely

closed and the slender antennæ consequently excluded from the orbit.

HARROVIA, *Adams & White.* (Plate XIII. fig. 11.) Carapace slightly tuberculate, lateral spine small. Front broad, truncated, and divided by three fissures into four lobes, of which the median are truncated and the lateral acute. Anterior legs elongated, ambulatory legs slender. Type *Harrovia albo-lineata*, Adams and White.

This genus was wrongly placed by Adams and White with the Leucosiidæ. By Stimpson it was considered synonymous with *Ceratocarcinus*; but it is as distinct as any other of the group. With the preceding, it appears to constitute almost a connecting link between the Parthenopinæ and the Eriphiidæ (*Trapezia*). As the specimens are dried and almost unique, I have not been able to examine the buccal cavity; but in the allied genus *Gonatonotus* there are clearly-marked longitudinal ridges on the endostome, as in the Eriphiidæ.

APPENDIX.

*GONIOTHORAX, *A. M.-Edwards.* This genus, which has been described since my paper was read, is allied, according to its author, to *Epialtus* and *Acanthonyx*, but differs in the length of the non-prehensile ambulatory legs and in the structure of the antennal region. The antennæ define the orbits below; their basal joint is small, not reaching to the summit of the antennulary fossæ; the two following joints are nearly as thick as the first, the third being remarkably long. Type *Goniothorax ruber*, A. M.-Edwards.

*LEPIDONAXIA, *Targioni-Tozetti.* I have not been able to consult the author's recently published 'Report on the Brachyurous and Anomourous Crustacea collected during the voyage of the corvette 'Magenta;'' but, to judge from the description of this genus, quoted by V. Martens in the 'Zoological Record' for 1877, it would seem to be allied to *Hyastenus*, differing, however, in the form of the basal antennal joint, which is dilated and unarmed externally, unidentate posteriorly and in the middle. Type *Lepidonaxia Defilippii*, Targ.-Tozetti.

PLATYLAMBRUS, *Stimpson.* This generic name was suggested by Stimpson in case it should be found practicable to separate from *Lambrus* the *L. crenulatus*, Saussure, and such allied species

as are characterized by a depressed carapace and excavated pterygostomian and subhepatic regions, this excavation forming, when the chelipedes are retracted, passages to the efferent branchial apertures.

This excavation, however, varies not only in direction and depth, but is traceable in species not otherwise very nearly allied; and I would suggest the following as more convenient subgeneric divisions:—

Subgenus 1. Lambrus. Carapace subrhomboidal, not produced at its postero-lateral angles over the bases of the ambulatory legs. Anterior legs greatly elongated and spinose (usually more than three times as long as the carapace). Type *Lambrus crenulatus*, Sauss.

Subgenus 2. Parthenopoides, *Miers*. Carapace subtriangular with the posterior margin nearly straight, and produced at the postero-lateral angles over the bases of the ambulatory legs. Anterior legs rarely spinose and of moderate length (rarely exceeding $2\frac{1}{2}$ times the length of the carapace). Type *Parthenopoides massena* (Roux).

This subgenus includes those *Lambri* which approach *Parthenope* in the lesser development of the anterior legs, and includes several species which have been described as members of that genus.

DESCRIPTION OF THE PLATES.

Plate XII.

Fig. 1. *Stenorhynchus rostratus* (Linn.). Front of the cephalothorax, dorsal view, showing the laterally projecting eyes and the absence of orbits; × nearly 3 diameters.

2. Inferior view of the same, showing the slender basal antennal joint and large epistome; × nearly 3 diam.

3. *Oregonia hirta*, Dana. Front of the cephalothorax, showing the projecting rim which covers the base of the ocular peduncle and the prominent postocular spine; × 3 diam.

4. Inferior view of the same, showing the form of the narrow basal antennal joint and of the epistome; × 3 diam.

5. *Xenocarcinus tuberculatus*, White. Inferior view of the front of the cephalothorax, showing the immobile eyes and the form of the basal antennal joint; × 3 diam.

6. *Acanthonyx lunulatus*, Risso. Inferior view of the front of the cephalothorax, showing the form of the basal antennal joint and the partial concealment of the eyes beneath the prominent præocular spine; × 3 diam.

Fig. 7. *Maia squinado*, Linn. Dorsal view of the front of the cephalothorax, showing the form of the upper orbital wall, which is formed of long spines, beneath which the long and slender eye-peduncles are retractile; natural size.

8. Inferior view of the same, showing the form of the inferior margin of the orbit and of the enlarged basal antennal joint; natural size.

9. *Pisa* (*Arctopsis*) *lanata*, Lamk. Dorsal view of the front of the cephalothorax, showing the narrow hiatus in the upper orbital margin and the short eye-peduncle; × 2 diam.

10. Inferior view of the same, showing the hiatus in the lower orbital margin and the basal antennal joint; × 2 diam.

Plate XIII.

Fig. 1. *Micippa cristata*, Leach. Inferior view of the front of the cephalothorax, showing the deflexed rostrum, greatly dilated basal antennal joint, and nearly complete orbits; natural size.

2. Lateral view of the orbit and deflexed rostrum; natural size.

3. *Criocarcinus superciliosus* (Herbst). Inferior view of the front of the cephalothorax, wherein the posterior part of the orbit is represented only by the postocular spine, and the anterior part surrounds the laterally projecting eye-peduncle in the form of a tube open below; natural size.

4. *Pericera cornuta*, Latreille. Inferior view of the front of the cephalothorax, showing the short epistome and greatly-developed basal antennal joint; natural size.

5. Lateral view of the orbital cavity (the eye-peduncle being removed) showing its circular form and complete margin; natural size.

6. *Othonia aculeata* (Gibbes). Inferior view of front of cephalothorax, showing the extreme development of the basal antennal joint (which has coalesced with the surrounding parts), the dilated second antennal joint, and obsolescent rostrum; × $1\frac{1}{2}$ diam.

7. *Mithrax hispidus*, Herbst. Dorsal view of the front of the cephalothorax, showing the form of the rostrum and orbits; natural size.

8. Inferior view of the same, showing the form of the epistome and basal antennal joint; natural size.

9. *Lambrus macrochelos*, Herbst. Inferior view of the front of the cephalothorax, showing the small antennæ inserted in the hiatus between the inner orbital angle and the front; × 2 diam.

10. *Œthra scruposa* (Linn.). Similar view of the front of the cephalothorax; natural size.

11. *Harrovia albolineata*, Ad. & White. Similar view of the front of the cephalothorax; × 3 diam.

Descriptions of new Species of Aculeate Hymenoptera collected by the Rev. Thos. Blackburn in the Sandwich Islands. By FREDERICK SMITH, F.Z.S. (Communicated by ARTHUR G. BUTLER*, F.L.S.)

[Read March 20, 1879.]

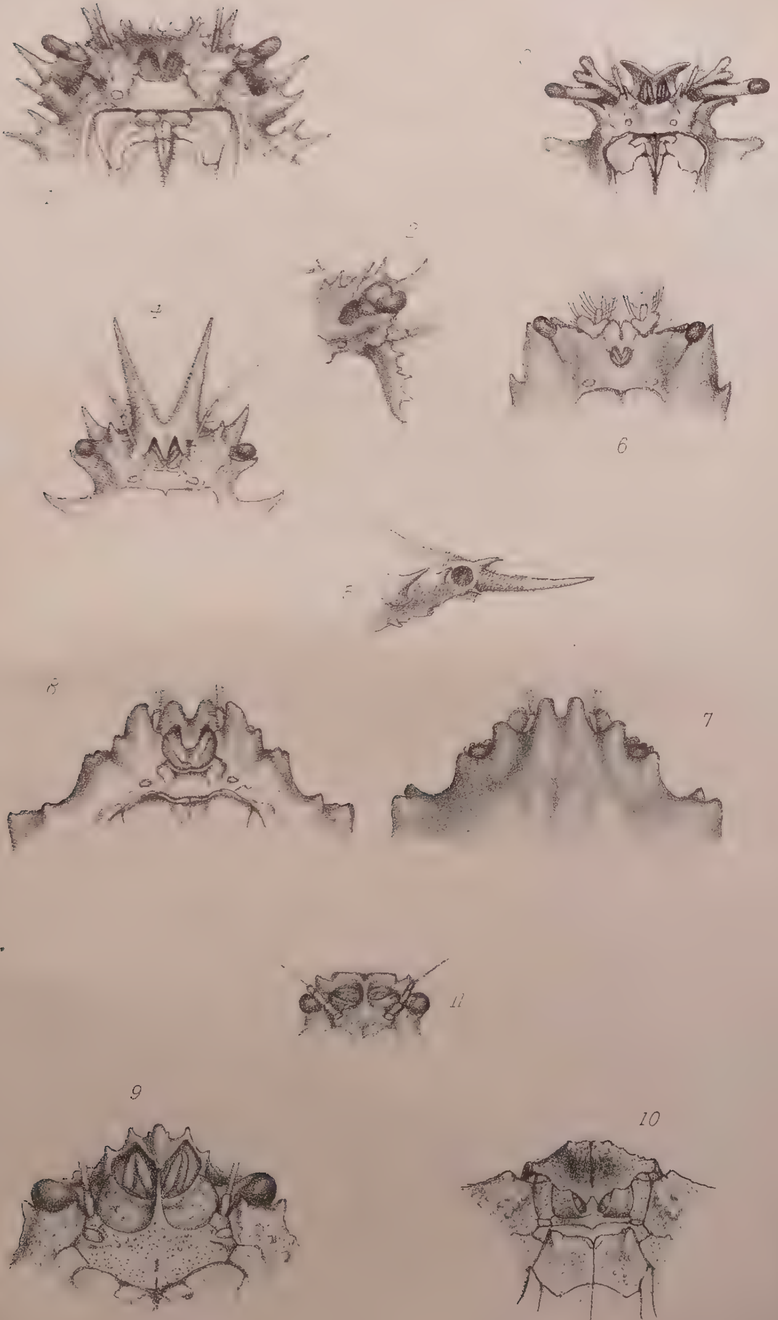
THIS small collection of Hymenoptera from the Sandwich Islands is an extremely interesting one. It is so not only from the circumstance of the locality being so completely isolated (the nearest point of land of the American continent, California, being about 2500 miles distant), but also in consequence of so little being known of the Hymenopterous fauna of these islands; only some half a dozen species are in the collections of the British Museum, which were obtained on Capt. Beechey's voyage.

The general aspect of the collection is certainly North-American, with a slight mixture of Californian, Mexican, and South-American species. The eight species of Ants are the most diverse in character. One, *Camponotus sexguttatus*, is distributed throughout Brazil and South America. Another, *Pheidole pusilla*, the house-ant of Madeira, observed and described by Professor Heer on his residence in the island, is said to be one of the commonest Ants in the Sandwich Islands, where it lives at large, nesting under stones; the species is cosmopolitan, and in northern latitudes takes up its abode in houses; it is also a common greenhouse species, and in London is found in bakehouses. Another of the Ants, *Solenopsis geminata*, has a wide geographical range; it is common in Calcutta, is found in most of the islands of the Eastern Archipelago, and also throughout South America and Brazil. The little European Ant, *Ponera contracta*, we should scarcely have expected to receive from so remote and isolated a locality; but both the female and worker are in the collection. Seven species of *Odyneri* are described as new on the authority of Dr. Saussure, whose work on the American Wasps is so well known. Of Apidæ, six species of *Prosopis* are in the collection, only one of which was previously described. A new species of *Megachile* and the common Hive-Bee (*Apis mellifica*) complete the list of the Bees.

* [The MS. of this paper was placed in my hands for publication subsequent to the death of the author.—A. G. B.]

STRUCTURE OF ORBITAL AND ANTENNAL REGIONS
OF THE MAIOID CRABS. (OXYRHYNCHA)

C.Berjeau lith. Hanhart imp.



STRUCTURE OF ORBITAL AND ANTENNAL REGIONS
OF THE MAIOID CRABS. (OXYRHYNCHA).

C. Berjeau lith   Hanhart imp

Fam. FORMICIDÆ.

CAMPONOTUS SEXGUTTATUS, *Fabr. Ent. Syst.* ii. p. 354. ♂ ♀ ☿.
Hab. Honolulu. South America; Brazil.
A nest of this ant occurred in an old drawer in a house (*T. B.*).

PRENOLEPIS CLANDESTINA, *Mayr, Neue Formiciden* (1870), p. 10.
Hab. Oahu. Java.

Fam. PONERIDÆ.

PONERA CONTRACTA, *Latr. Gen. Crust. et Ins.* iv. p. 128.—Formica contracta, *Latr. Hist. Nat. Fourm.* p. 195, tab. 7. fig. 40.
Hab. Oahu. South America; Madeira; Europe.
This species is rare; I have never found a nest. (*T. B.*)

LEPTOGENYS INSULARIS, n. sp. *Worker.* Length $3\frac{1}{2}$ lines. Opaque black, and thinly covered with ashy pile. Head widest anteriorly; the eyes ovate, placed forwards, at the sides near the base of the mandibles, which are falcate, and pointed at their apex, which is ferruginous; the flagellum of the antennæ rufo-testaceous, obscurely so above; the clypeus produced; the antennæ inserted at the sides of a prominence above the clypeus. Thorax oblong, compressed from the prothorax to the apex of the metathorax; the tarsi more or less rufo-testaceous. Abdomen oblong, posteriorly narrowed to the apex; the node of the peduncle subglobose, of the width of the metathorax, but narrower than the first segment of the abdomen, which is slightly constricted; the apical segment pale ferruginous, and with a few fulvous hairs.
Hab. Island of Oahu.
Not rare; it forms its nest under stones; workers only taken. (*T. B.*)

Fam. MYRMICIDÆ.

TETRAMORIUM GUINEENSE, *Fabr. Ent. Syst.* ii. p. 357. ☿.
Hab. Oahu. Guinea.

PHEIDOLE PUSILLA, *Heer, Ueber die Hausameise Madeira's* (1852); *Ann. & Mag. Nat. Hist.* (1856) xvii. p. 221. ♂ ♀ ☿ major, ☿ minor.
Hab. Honolulu.
One of the commonest Ants here, forming its nests under stones. The nests always contain three forms; but I have never found the male. (*T. B.*)

Solenopsis geminata, *Mayr & Roger.*—Solenopsis cephalotes, *Smith, Journ. Proc. Linn. Soc.* iv. p. 140. ☿ major.—Atta geminata, *Fabr. Syst. Piez.* p. 423.

Hab. Honolulu. South America; India; Aru, Celebes, Batchian.

I found a single nest in a palm-tree, which seemed to contain no other sex than the worker; it stings very venomously. (*T. B.*)

Fam. Sphegidæ.

Pelopœus flavipes, *Fabr. Syst. Piez.* p. 204.

Hab. Honolulu. North America; Mexico.

Very abundant everywhere. I have caught the female carrying spiders. (*T. B.*)

Fam. Larridæ.

Pison iridipennis, n. sp. *Male.* Length 3 lines. Black; head and thorax finely and closely punctured, and slightly shining; abdomen shining, and very delicately punctured. The face with silvery-white pubescence as high as the emargination of the eyes; the palpi rufo-testaceous. The metathorax obliquely and finely striated; having a central longitudinal channel, and with silvery-white pubescence laterally; the wings hyaline and splendidly iridescent, the nervures black; the legs with silvery pile, which is very bright on the posterior tibiæ within. Abdomen—at the basal margin of the second segment laterally a little silvery-white pubescence, on the apical margins of the segments laterally a little silvery pile, only observable in certain lights.

Hab. Honolulu.

Rare; a single female taken, which differs sexually as in the following species. (*T. B.*)

Pison hospes, n. sp. *Female.* Length $5\frac{1}{4}$ lines. Black, shining, with the head and thorax closely and finely punctured, the abdomen with fasciæ of silvery-white pubescence. Head—the face below the antennæ with bright silvery pubescence, also a line on the margin at the inner orbit of the eyes, as high as their emargination; the anterior margin of the clypeus rounded. Thorax—the hinder margin of the prothorax with a little silvery-white pubescence, and also on the sides of the metathorax, which has a deep central longitudinal channel; the wings subhyaline, the nervures black; the legs covered with silvery pile; the calcaria black. Abdomen much more finely and closely punctured than the thorax; the segments slightly constricted; the apical

margins of the segments with fasciæ of fine silvery pubescent pile, which are very brilliant in certain lights, and which are widened laterally.

The *male* only differs in being smaller and in having an additional joint in the antennæ and an extra segment to the abdomen.

A common but not abundant species; it was taken in the islands of Oahu, Kauai, and Maui. Mr. Blackburn says that he has bred this species from the same collection of cells as those which produced species of *Pelopœus* and of *Crabro*. This observation appears to indicate the habit of the genus to be parasitic; but this cannot be the case, their economy having been observed and published by Mr. Horne in the seventh volume of the Transactions of the Zoological Society. The species construct cells of mud, which they provision with spiders, the food of their young brood. The genus *Crabro* usually provisions its cells with Diptera.

Fam. CRABRONIDÆ.

CRABRO AFFINIS, n. sp. *Female.* Length $4\frac{1}{2}$ lines. Black; the abdomen shining, and having two yellow fasciæ, the first interrupted. Head and thorax semiopaque; the former with the ocelli in a curve on the vertex; the basal half of the mandibles and the scape of the antennæ in front yellow; the clypeus with a longitudinal carina, and thinly covered with silvery pile. Thorax—the mesothorax with two abbreviated longitudinal ridges on the disk; the scutellum obsoletely bituberculate; the metathorax with a central longitudinal channel; wings subhyaline, the nervures black; the outer margin of the tegulæ flavo-testaceous. Abdomen with a slightly interrupted yellow fascia on the basal margin of the second segment; and a narrow uninterrupted one near the basal margin of the fourth; the apical margin of the fifth segment narrowly flavo-testaceous, and fringed with short white pubescence; the sixth segment with a few scattered punctures.

Hab. The island of Kauai.

This species was captured very sparingly. It resembles the *C. vagus* of Europe, and belongs to the same division of the genus, having the ocelli in a curve, the *Solenus* of St. Fargeau.

CRABRO MANDIBULARIS, n. sp. *Female.* Length 5 lines. Black, and slightly shining; the head and thorax very closely and finely punctured, and having a few yellow markings. Head—the ocelli in a curve on the vertex; the clypeus and anterior margin

of the face with bright golden-coloured pubescence; the scape of the antennæ in front, and the basal half of the mandibles above, yellow; the cheeks with changeable silvery pile. Thorax—a minute spot on the collar laterally, the tubercles, and the postscutellum yellow; the wings hyaline, the nervures black; the metathorax with a central longitudinal channel, and a few short carinæ at its extreme base, and without the usual enclosed semicircular space at its base. Abdomen smooth and shining, the three or four apical segments with thin short white pubescence; the apical segment with the margins raised, shining, and with a few strong punctures.

Hab. Coasts of Maui.

Taken on flowers on sandy coasts. (*T. B.*)

Crabro denticornis, n. sp. *Male.* Length 3–4 lines. Black; the head and thorax slightly shining, the abdomen smooth and shining. Head—the ocelli in a curve on the vertex; the fifth joint of the flagellum produced beneath into a tooth or tubercle; the clypeus with bright silvery pubescence; the mandibles bidentate at the apex, and having a large acute tooth on their inner margin. Thorax—the postscutellum yellow and subinterrupted in the middle; the scutellum slightly bituberculate; the metathorax with a central longitudinal channel, slightly impressed at the base and deeply so towards the apex; wings fusco-hyaline, palest at their base. Abdomen smooth, shining, and impunctate; occasionally the second segment has a small yellow spot laterally.

Hab. Sandy coasts of Maui.

This may possibly be the male of *C. iridipennis*; but the silvery clypeus and dark wings obliged me to hesitate about uniting them.

Crabro unicolor, *Smith, Cat. Hym. Ins.* pt. iv. p. 421. ♀.

Hab. Honolulu.

Fam. Eumenidæ.

Group of Odynerus pratensis, *Saussure's American Wasps*, p. 292.

Odynerus localis, n. sp. *Female.* Length 7 lines. Head and thorax not strongly but very closely punctured; the clypeus convex, strongly punctured and truncate at the apex. Thorax—the puncturing of the mesothorax is a mixture of large and small ones; the postscutellum with strong punctures and crenulated; the metathorax rugose and truncate; wings dark shining reddish brown. Abdomen shining, truncate at the base, but not sharply ridged; the first and second segment with very fine distant punctures, the puncturing being strongest and closest at the base of

the second segment; the third and following segments with stronger punctures than the first or second; the apical margins of the first and second segments with white fasciæ, that on the first narrower than that on the second.

The *male* only differs in the usual sexual difference in the structure of the antennæ and abdomen; but the white bands on the abdomen are narrower, and the basal segment is rounded, not truncate.

Hab. Kauai.

Abundant on the island Kauai, but not found anywhere else. (*T. B.*)

Odynerus maurus, n. sp. *Female.* Length $6\frac{1}{2}$ lines. Entirely black, with dark fuscous wings that have a violet iridescence, and some semifusco-hyaline spots about the second and third submarginal cells. The head and thorax very closely punctured; the clypeus with stronger punctures, its apex truncate, concave, and with the lateral angles sharp and apparently bidentate. Thorax—the scutellum flattened; the postscutellum rugose, and with the margin crenulated; the metathorax truncate, having a central longitudinal channel, on each side of which it is obliquely rugose-striate. Abdomen—the basal segment obtusely rounded, not ridged, and, as well as the second segment, with very fine, distant, shallow punctures; the apical margin of the second segment and the following segments with distant large shallow punctures.

The *male* is smaller, but closely resembles the female; the hooked joint at the apex of the antennæ is ferruginous.

Hab. Honolulu &c.

Apparently common all over the Archipelago, constructing mud-nests of 1 to 10 cells against stones, trunks of trees, &c., under eaves of houses, often inside houses. (*T. B.*)

Group of Odynerus vagus, *Saussure's American Wasps*, p. 314.

Odynerus rubritinctus, n. sp. *Female.* Length $4\frac{1}{2}$ lines. Black, with the postscutellum, the metathorax, basal segment of the abdomen, and the lateral and apical margins of the second segment dark blood-red. Head—a triangular red spot at the insertion of the antennæ above; the clypeus convex, narrowed anteriorly, its apex truncate, the lateral angles of the truncation subdentate. Thorax—a red spot beneath the wings, and a minute one on the tegulæ in front and behind; the thorax, as well as the head, closely and not very strongly

punctured; the scutellum flat, and with a central longitudinal impressed line; the metathorax concave-truncate, the cavity black; wings dark fuscous, with a violet iridescence, along the course of the nervures is a more or less hyaline line. Abdomen shining; the first segment campanulate, and with rather strong distant punctures; the rest of the segments more finely punctured; the red lateral margins of the second segment have a united red spot.

Male. Length $3\frac{1}{2}$ lines. Very closely resembling the female; the terminal hook of the antennæ red. Thorax—two ovate spots on the scutellum, also two beneath wings, frequently united; the second segment of the abdomen has a larger spot at the sides, and no red band on the apical margin.

Hab. Kauai.

This species is not rare on Kauai. (*T. B.*)

Group of Odynerus totonacus, *Saussure's American Wasps*, p. 346.

Odynerus montanus, n. sp. *Female.* Length 6 lines. Entirely black and shining; wings deep brown-black, with a violet iridescence, very brilliant; the stigma and costal nervures bright steel-blue. The clypeus convex, finely punctured, with the apex truncate. Thorax not so strongly or closely punctured as the head; the scutellum flat, the postscutellum slightly convex, shining, and sparingly punctured; the metathorax concave-truncate; having a central longitudinal channel; obliquely rugulose in the middle, the sides coarsely rugose. Abdomen—the first segment campanulate, strongly but not very closely punctured, the apical margin rebordered; the second segment very convex, elevated to a subconical shape, finely and not very closely punctured; its apical margin, as well as the following segments, with large shallow punctures.

Male. Length $5\frac{1}{2}$ lines. Closely resembling the female; the clypeus more strongly punctured, the terminal hook of the antennæ rufo-piceous, the thorax and abdomen as in the female.

Hab. Mountains of Oahu, where it is common. (*T. B.*)

Odynerus congruus, n. sp. *Female.* Length $4\frac{3}{4}$ lines. Black, punctured, and shining; the wings fusco-hyaline, with a dark fuscous stain along the anterior margin of the front pair. The head with distant fine punctures; the clypeus very convex, and with a small truncate projection at its apex, impunctate, or with only a few very fine distant punctures. Thorax smooth and shining

above, having only a few very fine shallow punctures; the scutellum slightly convex; the metathorax opaque, oblique, and with rather large shallow indentations, the lateral margins rounded, without any excavation; the claws of the tarsi ferruginous. Abdomen—the first segment campanulate, as long as broad, finely, evenly, but not very closely punctured; the second segment large, impunctate, or with only a few very fine shallow punctures, its apical margin, as well as the following segments, with shallow fine punctures.

Male. Smaller than the female, but of the same form and similarly sculptured; differs in having, at the apex of the clypeus, two little pale yellow lines, and also a small ovate-yellow spot just above the insertion of the antennæ; the terminal hook of the antennæ and claw-joint of the tarsi ferruginous.

Hab. Honolulu.

This species is not rare. (*T. B.*)

Odynerus dubiosus, n. sp. *Male.* Length 4 lines. Black, with fuscous wings, not very dark, but with bright violet iridescence. Head closely punctured; the clypeus impunctate, or with a very few fine shallow punctures; its apex notched above, giving it the appearance of being bidentate; the terminal hooks of the antennæ pale at their tips. Thorax punctured, not strongly so; the lateral angles of the prothorax acute; the scutellum and postscutellum only slightly convex, and sparingly punctured; the metathorax with confluent rather shallow punctures, concave in the middle, with the sides rounded; the scutellum with a central longitudinal impressed line. Abdomen—the first segment campanulate, as broad as long, and evenly punctured; the second segment large, convex, the sides rounded; impunctate, or with only a few very fine shallow punctures; the following segments with fine shallow punctures, but stronger than those on the second segment.

Hab. Honolulu.

Odynerus agilis, n. sp. *Male.* Length $4\frac{1}{2}$ lines. Black, with a narrow yellow fascia on the apical margins of the first and second segments. Head very closely punctured; a minute yellow spot between but a little above the insertion of the antennæ; the clypeus very convex, and bidentate at the apex; the terminal hook of the antennæ obscurely testaceous; the entire insect with a fine cinereous pile, which is most dense on the head and thorax. Thorax—the scutellum rather convex, and with a central lon-

gitudinal impressed line; the metathorax concave-truncate; wings subhyaline, with a fuscous line along the costal and marginal cells; the wings iridescent. Abdomen—the basal segment campanulate, and with very shallow punctures; the second segment with very fine shallow punctures; the apical segment with shallow punctures.

Hab. Maui.

Apparently rare; I have not seen the female. (*T. B.*)

Fam. Vespidæ.

Polistes aurifer, *Sauss. Mon. Guêpes Soc.* p. 78.

Hab. Honolulu. California.

Fam. Andrenidæ.

Prosopis Blackburni, n. sp. *Female.* Length 3 lines. Black, and closely resembling the female of *P. facilis*, but has the flagellum of the antennæ fulvous beneath. The metathorax with a few short striæ at the base; wings subhyaline and iridescent, the recurrent nervures uniting with the transverse nervures of the second submarginal cell, as in *P. facilis*. The abdomen smooth, shining, and impunctate.

Male. The size of the female; the front of the head as high as the antennæ, yellow, the scape with a yellow line in front, the flagellum fulvous beneath. The tibiæ and tarsi yellow, with a small black spot on the tibiæ behind, and the apical joint of the intermediate and posterior tarsi fusco-ferruginous; wings and abdomen as in the female.

Hab. Island of Maui.

It will be seen that the male of this species differs greatly in colouring from the same sex of *P. facilis*, although the females have little specific distinction.

Prosopis fuscipennis, n. sp. *Male.* Length 4¼ lines. Black, the head and thorax semiopaque; the abdomen smooth, very finely punctured, sparsely so at the base, bright and shining; wings fuscous, inclining to fulvous, and brightly iridescent. The head closely and finely punctured; the clypeus somewhat produced, and truncate anteriorly; the scape of the antennæ compressed, its lower margin narrowly white. Thorax—the margin of the prothorax white; the mesothorax and scutellum closely punctured; the metathorax rugose; the anterior tibiæ and tips of the

femora fulvous within, and the four apical joints of the tarsi rufo-testaceous.

Hab. Sandwich Islands.

This species occurs rarely on the mountains of Oahu. I possess a single female, which differs from the male in having the body shorter and stouter, with the terminal ventral segments pointed, and the basal joint of the antennæ narrow and cylindrical. (*T. B.*)

Prosopis facilis, n. sp. *Female.* Length $3\frac{1}{3}$ lines. Black; the head and thorax very closely and finely punctured; abdomen shining and impunctate. Head suborbiculate; the clypeus coriaceous, with some large shallow punctures. The mesothorax with a short impressed line over the tegulæ; the metathorax with short longitudinal striæ at the base, the sides having a little white pubescence; the wings fusco-hyaline, hyaline at their base, and brightly iridescent. Abdomen smooth, shining, and impunctate.

Male. Very like the female, but more slender; the clypeus and a line at its lateral margins, on the face, yellow; the scape of the antennæ swollen, but black. The anterior tibiæ and tarsi in front, and also the apex of the femora, yellow; the wings paler than in the female; the base of the intermediate and posterior tibiæ rufo-testaceous. Abdomen oblong-ovate, smooth, shining, and impunctate.

Hab. Island of Maui.

Prosopis hilaris, n. sp. *Male.* Length 3 lines. Head and thorax black, the two basal segments and the base of the third ferruginous. Head—the front as high as the antennæ, and on each side, along the margin of the eyes, a little above them, yellow; the scape of the antennæ and the mandibles yellow, the latter ferruginous at their tips; the scape dilated; the flagellum ferruginous. Thorax—the legs ferruginous, with the coxæ and femora towards their base black; wings hyaline and iridescent, their apex faintly clouded; the metathorax subrugose. Abdomen smooth and shining.

Hab. Occurs rarely on flowers in the island of Maui. (*T. B.*)

Prosopis volatilis, n. sp. *Male.* Length 3 lines. Head and thorax black, the two basal segments of the abdomen ferruginous. Head—the front, below the antennæ, yellow; the flagellum fulvous and more or less fuscous above; the scape has a fulvous line in front; the mandibles ferruginous towards their apex. Thorax—the anterior tibiæ, tarsi, and tips of the femora ferrugi-

nous; the metathorax finely rugulose, opaque, and with a few short striæ at the base; wings subhyaline, iridescent, and faintly clouded at their apex. Abdomen smooth and shining; the apical margin of the second segment, and the following segments, black.

Hab. Island of Kauai.

Taken sparingly on flowers. (*T. B.*)

Fam. Apidæ.

Megachile diligens, n. sp. *Female.* Length 4½ lines. Black; the pubescence on the head and thorax obscure pale fulvous, becoming cinereous on the metathorax and on the face anteriorly; the abdomen with ferruginous pubescent fasciæ. Head—the mandibles with four teeth, the two apical ones acute, the others blunt; the cheeks with long cinereous pubescence; the legs with a little short black pubescence above, on the tarsi beneath it is reddish brown; the claws ferruginous, tipped with black; wings subhyaline, the nervures black. Abdomen cordate, and densely clothed with bright ferruginous pubescence beneath.

Male. Rather smaller than the female, but very closely resembling it. Differs in having the clypeus densely covered with very pale fulvous pubescence; the anterior tarsi fringed behind with pale pubescence; the fifth and sixth segments of the abdomen densely clothed above with short ferruginous pubescence; the sixth segment deeply emarginate, forming two blunt apical teeth.

Hab. Honolulu.

Not rare; forming nests of leaves of a species of Acacia rolled up into cylindrical cells, which are joined one at the end of another to the length of several inches, and are placed in crevices of masonry. (*T. B.*)

Xylocopa æneipennis, *De Geer*, *Mém.* iii. p. 573, tab. 28. fig. 8, ♀; *St. Farg. Hym.* ii. p. 186, ♀.

The *male* is ferruginous and clothed with fulvous pubescence; the mandibles black, with a pale spot at their base; the scape of the antennæ above and the second joint of the flagellum black. Thorax black beneath; the anterior trochanters black, with a pale ferruginous spine beneath; the intermediate and posterior coxæ and trochanters, and also the femora, black; wings flavo-hyaline, with ferruginous nervures. The apex of the abdomen pubescent in the form of two dense tufts.

Hab. Honolulu. Mexico; Peru; South America; Brazil.

Very abundant and destructive, boring long galleries in wood, with apparent indifference whether the wood be dead or living. (*T. B.*)

Apis mellifica, *Linn. Syst. Nat.* i. p. 955.
Hab. Sandwich Islands, &c. &c.

Contributions to the Ornithology of New Guinea. By R. Bowdler Sharpe, F.L.S., F.Z.S. &c.—Part VI. On Collections made by the Rev. W. G. Lawes in South-eastern New Guinea.

[Read April 17, 1879.]

The collections which have been made in the neighbourhood of Port Moresby during the last few years seem to have tolerably well exhausted the ornithology of that part of New Guinea, and each consignment which reaches England is more or less a repetition of those which have gone before. The Rev. Mr. Lawes, however, has made a small collection of birds; and as he has visited one or two places to the eastward of Port Moresby, I have thought it advisable to give a list of his specimens, as the range of the birds in an easterly direction is one of considerable interest to the student of the avifauna of South-eastern New Guinea.

Walter Bay, Mr. Lawes informs me, is situated a few miles to the east of Port Moresby; but Hood Bay is about sixty miles east of the last-mentioned place. I have referred to my former paper on Mr. Stone's collection (Journ. Linn. Soc. xiii. p. 486). The "Laroki" river there mentioned is the same as the Laloke river of the present paper, as Mr. Lawes tells me the latter is the more correct pronunciation.

1. Haliastur girrenera (*V.*); *Sharpe, Journ. Linn. Soc.* xiii. p. 490. Walter Bay.

2. Microglossum aterrimum (*Gm.*); *Sharpe, t. c.* p. 491. Hood Bay.

3. Geoffroyius aruensis (*Gray*); *Sharpe, t. c.* p. 491. Laloke River.

4. Cyclopsitta suavissima, *Sclater*; *Sharpe, t. c.* p. 491. Laloke River.

5. Trichoglossus massena, *Bp.*; *Sharpe, t. c.* p. 491. Hood Bay; Laloke River.

6. Chalcopsittacus scintillatus (*Temm.*); *Salvad. Ann. Mus. Civic. Genov.* xiv. p. 37. Hood Bay; Laloke River. Count Salvadori, in his account of Signor D'Albertis's Fly-River collections, has reunited his *C. chloropterus* of South-eastern New Guinea to *C. scintillatus*, which conclusion appears to me to be perfectly correct.

7. Eos fuscata, *Blyth*; *Sharpe, anteà*, p. 628. Walter Bay.

8. Eclectus polychlorus (*Scop.*); *Sharpe, op. cit.* xiii. p. 491. Port Moresby; Laloke River.

9. Scythrops novæ-hollandiæ, *Lath.*; *Sharpe, t. c.* p. 492. Walter Bay.

10. Merops ornatus, *Lath.*; *Salvad. Ann. Mus. Civic. Genov.* xiv. p. 47. "A very common bird on the coast and inland. Lays eggs in sand" (*W. G. Lawes*).

11. Dacelo intermedius, *Salvad.*; *Sharpe, t. c.* p. 493. Laloke River.

12. Dacelo Gaudichaudi (*Less.*); *Sharpe, t. c.* p. 493. Hood Bay.

13. Rhytidoceros ruficollis, *V.*; *Sharpe, t. c.* p. 493. Hood Bay; Laloke River.

14. Eurystomus crassirostris, *Sclater*; *Sharpe, t. c.* p. 493. Laloke River.

15. Eurystomus pacificus (*Lath.*); *Salvad. Ann. Mus. Civic. Genov.* xiv. p. 53. Walter Bay.

16. Halcyon sancta, *V. & H.*; *Sharpe, t. c.* p. 492. Laloke River.

17. Halcyon Macleayi, *J. & S.*; *Sharpe, t. c.* p. 492. Laloke River.

18. Syma torotoro, *Less.*; *Sharpe, t. c.* p. 492. Walter Bay.

19. Tanysiptera michrorhyncha, *Sharpe*; *id. t. c.* p. 493. Walter Bay.

20. Podargus papuensis, *Q. & G.*; *Sharpe, t. c.* p. 493. Walter Bay.

21. PITTA NOVÆ-GUINEÆ, *M. & Schl.*; *Sharpe, t. c.* p. 494. Laloke River.

22. CHLAMYDODERA CERVINIVENTRIS, *Gould*; *Salvad. t. c.* p. 495. Port Moresby.

23. TROPIDORHYNCHUS NOVÆ-GUINEÆ, *S. Müll.*; *Sharpe, t. c.* p. 497. Laloke River.

24. MONARCHA MELANOPSIS, *V.*; *Sharpe, Cat. B.* iv. p. 430. Laloke River.

25. MALURUS ALBISCAPULATUS, *Meyer*; *Sharpe, Cat. B.* iii. p. 297. Laloke River; Walter Bay.

26. CRACTICUS CASSICUS (*Bodd.*); *Sharpe, Journ. Linn. Soc.* xiii. p. 499. Laloke River.

27. CRACTICUS MENTALIS, *Salvad. & D'Albert.*; *Sharpe, t. c.* p. 499. Laloke River.

28. ORIOLUS STRIATUS, *Q. & G.*; *Sharpe, t. c.* p. 500. Walter Bay.

29. SPHECOTHERES SALVADORII, *Sharpe*; *t. c.* p. 500. Port Moresby; Laloke River.

30. PSEUDORECTES FERRUGINEUS (*Bp.*); *Sharpe, Cat. B.* iii. p. 287. Laloke River.

31. CHIBIA CARBONARIA (*Müll.*); *Sharpe, t. c.* p. 499. Laloke River.

32. PARADISEA RAGGIANA, *Sclater*; *Sharpe, t. c.* p. 500. Laloke River. A considerable series. All the specimens are true *P. raggiana*, and do not exhibit any of the curious hybridization with *P. novæ-guineæ* noticed by Signor D'Albertis on the Fly River. (*Cf.* Salvad. Ann. Mus. Civic. Genov. xiv. p. 80.)

33. CORVUS ORRU, *Müll.*—Corone orru, *Sharpe, t. c.* p. 501. Akeva River, Hood Bay; Laloke River.

34. EULABES DUMONTI (*Less.*); *Sharpe, t. c.* p. 501. Walter Bay; Laloke River.

35. MELANOPYRRHUS ROBERTSONI, *Sharpe, anteà*, p. 633. Laloke River.

36. CALORNIS VIRIDESCENS, *Gray*; *Sharpe, Journ. Linn. Soc.* xiii. p. 501. Walter Bay; Hood Bay; Laloke River.

37. Artamus leucorhynchus (*L.*).—A. leucogaster, *Salvad. Ann. Mus. Civic. Genov.* xiv. p. 69. Port Moresby.

38. Donacola nigriceps, *Ramsay*; *Sharpe, t. c.* p. 501. Laloke River.

39. Munia caniceps, *Salvad. Ann. Mus. Civic. Genov.* ix. p. 38. Port Moresby; Laloke River. "These Finches come in flocks about September, and feed on seeds of the dried grasses" (*W. G. Lawes*).

40. Campophaga spilorrhoa, *Gray*.—Myristicivora spilorrhoa (*Gray*); *Salvad. Ann. Mus. Civic. Genov.* ix. p. 276. Laloke River.

41. Carpophaga Muelleri, *Temm.*; *Sharpe, t. c.* p. 502. Laloke River.

42. Carpophaga pinon (*Q. & G.*); *Sharpe, t. c.* p. 502. Laloke River.

43. Carpophaga puella (*Less.*); *Sharpe, t. c.* p. 503. Laloke River.

44. Ptilonopus aurantiifrons, *Gray*; *Sharpe, t. c.* p. 503 Laloke River.

45. Ptilonopus iozonus, *Gray*; *Sharpe, t. c.* p. 503. Walter Bay.

46. Ptilonopus coronulatus, *Gray*; *Sharpe, t. c.* p. 503. Laloke River.

47. Goura Albertisii, *Salvad.*; *Sharpe, t. c.* p. 503. Laloke River.

48. Geopelia humeralis (*Temm.*); *Sharpe, t. c.* p. 503. Walter Bay.

49. Lobivanellus miles (*Bodd.*); *Sharpe, t. c.* p. 504. Laloke River.

50. Ardea sacra, *Gm.*; *Sharpe, t. c.* p. 504. Port Moresby.

51. Porphyrio melanopterus, *Temm.*; *Sharpe, t. c.* p. 505. Port Moresby.

52. Tadorna radjah, *Garn.*; *Sharpe, t. c.* p. 505. Laloke River.

53. Tachypetes minor (*Gm.*).—Fregata minor, *Salvad. Ucc. Born.* p. 364. Port Moresby. One specimen of the smaller Frigate-bird was also in Mr. Goldie's collection.

On the Occurrence of *Morrhua macrocephala** at the Mouth of the Thames. By Francis Day, F.L.S.

[Read April 17, 1879.]

(Plate XIV.)

In the month of January this year I obtained, through the kindness of Mr. Carrington, Naturalist to the Royal Westminster Aquarium, an example of a large-headed Cod-fish, which had been captured at Southend, at the mouth of the Thames, but had died during its transit between there and London. A second example, stated to have been exactly similar, was taken along with the one alluded to, but unfortunately was not preserved. I believe this to be a species distinct from the Common Cod, *Morrhua vulgaris*, perhaps identical with Yarrell's "Lord-fish," likewise captured at the mouth of the Thames, while it certainly agrees with the description and figure of *Gadus macrocephalus*, Tiles. (Mém. Acad. Sc. St. Pétersb. ii. 1810, p. 350, t. xvi.), in most particulars, a species Swainson ('Fishes,' ii. p. 300, 1839) termed *Cephus macrocephalus*.

Yarrell (1836) gave a woodcut of the example which he obtained but omitted to preserve; and a comparison of his drawing with the figure appended to this paper will show that the proportions of the two specimens were very similar. Yarrell, however, mentions that by the fishermen it was considered to be only an accidental deformity, some injury to the spine having prevented the usual growth. There is reason to believe that the Speckled Cod of Dr. Turton, represented in his 'British Fauna' as frequently taken in the weirs at Swansea, is only the young of the Common Cod. The fishermen, according to Yarrell, however, appear to have been divided in opinion, as some said it was a fish which they met with occasionally, and believed it distinct from any other.

Dr. Cobbold (Proc. Royal Physical Soc. Edinb. 1854–58, i. p. 51), in a paper on the "Lord-fish" of Yarrell, stated that the example he possessed "consisted of a remarkable shortening of the body, arising from the coalescence of a great number of the vertebræ immediately succeeding the bones of the head. In the present example 21 were united together, and the shortening thus produced had given to the animal a curiously grotesque appearance. The middle dorsal fin was shortened, and the lateral longitudinal line

* In the 'Zoological Record' for 1870, p. 95, this fish is erroneously referred to as *Gadus macrophthalmus*.

arched very suddenly over the pectoral fins. Length, about 20 inches; depth, 8 inches. It corresponded very closely with the figure and description of this variety given in the second edition of Yarrell's British Fishes, vol. ii. p. 229."

Dr. J. Alexander Smith (Proc. Roy. Phys. Soc. Edinb. vol. iii. p. 302, 1864–65) gave descriptions of some deformed, hump-backed cod which he referred to *Gadus* (*Morrhua*) *punctatus*, Turton, and the "Lord-fish" of Yarrell. He mentions that Mr. Bargh stated these fish were not uncommon at this particular season of the year, and that in a take of six or seven dozens of cod from the long lines baited with the lug-worm, and laid on the north side of the Firth of Forth, six or seven of this variety were taken.

Dr. Dyce (Ann. & Mag. Nat. Hist. 1860, v. p. 366), after expressing his doubts about Turton's *Gadus* (*Morrhua*) *punctatus*, continues:—"While Yarrell, besides transcribing the descriptions of these authors, . . states that a fresh example was brought him, caught at the mouth of the Thames, which the fishermen called 'Lord-fish,' and considered to be an accidental deformity. Thus, though each has suspected its existence, there has been no attempt made at removing the doubt." He concludes that, having obtained numerous examples, he was in possession of facts sufficient to set these doubts at rest—that, in short, the "Lord-fish" is a Common Cod unnaturally shortened, due to spinal disease, suffering from a species of rickets.

Thus Dr. Dyce, after having demonstrated the fact that the cod-fish and some members of the cod family suffer from a disease which occasions a shortening of the length of the spinal column, came to the conclusion that such deformed examples were identical with Yarrell's "Lord-fish" and the *Gadus* (*Morrhua*) *punctatus*, Turton, stated to have a large head and the lateral line nearer the back than in the "common cod," curved as far as the middle of the second dorsal fin, growing broader and whiter towards its posterior end, and a considerably longer lower jaw: he does not allude to the upper jaw.

The formula of the fin-rays is as follows:—

Gadus punctatus, Turton. D. 14 | 20 | 18. A. 19 | 16.

Lord-fish, Yarrell. D. 14 | 19 | 18. A. 17 | 11.

Gadus macrocephalus (Tiles.), Kner & Steind. D. 14 | 17 | 18–19. A. 20–21 | 22?

Present example. D. 11 | 14 | 16. A. 16 | 11.

If we examine Yarrell's figure of his "Lord-fish," it does not

F. Day, del. C. Achilles, lith.

show an arched back or "a curiously grotesque appearance," the fish being apparently well formed. But, putting aside that specimen, I would remark upon my present example obtained from the same locality.

Length of head rather exceeding one third of the total length. Height of body nearly two thirds of the length of the head. Eyes large, diameter one fourth of the length of the head, $1\frac{1}{3}$ diameter from the end of the snout and one transverse diameter apart. The maxilla reaches to beneath the middle of the orbit; its length is a half of that of the head. Body in good condition. *Fins*: the origin of the first dorsal is midway between the end of the snout and the posterior end of the base of the last dorsal fin, it is rather elevated and pointed; the middle dorsal fin rather low; the third dorsal fin similar to the first. Second ventral ray rather prolonged. Pectoral reaches to above the vent, the latter being beneath the first ray of the second dorsal fin. *Lateral line* curved to below the middle of the second dorsal fin.

Having as yet this single example, I have been unwilling to sacrifice it in order to examine the spine, which I would not hesitate doing did I possess a second specimen. I would suggest the following reasons why this fish cannot be a deformed *Morrhua vulgaris* occasioned by spinal disease.

If the differences were entirely caused by disease of the spine posterior to the head, it is to be supposed that the head itself would remain unaffected; but here it is not so; and in comparing it with an example of the Common Cod of the same length, and captured at the same time, I find as follows:—

Morrhua vulgaris. Eye $\frac{1}{5}$ of head; upper jaw $\frac{2}{5}$ of length of head; vent midway between end of snout and base of caudal fin.

Morrhua macrocephala. Eye $\frac{1}{4}$ of head; upper jaw $\frac{1}{2}$ of length of head; vent midway between end of snout and beyond end of caudal fin.

The proportions as regards the eye and upper jaw do not appear to have been recorded in the examples from Scotland.

It will be seen that the vent is directly below the commencement of the second dorsal fin, exactly as in *Morrhua vulgaris*; consequently if this example is merely a deformed specimen, such would lead us to expect that the deformity would be posterior to the vent. But the first dorsal fin, which is anterior to it, has only 11 instead of 14 rays, and is much more angular than in the Common Cod.

This fish, I suppose, may be *Gadus punctatus*, Turton, of which

Fleming observed, "I would venture to suggest that it is only a variety of *Gadus morrhua*."

It agrees with *Gadus macrocephalus*, Tiles.; but unfortunately that author does not record the number of fin-rays. However, the length of the head, size of the eye, extent of the upper jaw, and the elongated ventral ray are the same. Tilesius's example came from Kamtschatka; Kner and Steindachner's from Decastris Bay.

Gadus callarias (Bloch), Griffith in Cuv. Animal Kingdom, x. p. 484, may be this species, which he observes has the upper jaw longer than in *Gadus morrhua*; but such is not shown in Bloch's figure, which appears to represent the Common Cod.

The "Lord-fish" of Yarrell appears to differ from this specimen in the eye being smaller and the upper jaw shorter; but it must be remembered that only a coloured figure was kept. The number of rays in the fins of fishes of this genus are subject to considerable variation; but if Turton's, Yarrell's, Kner and Steindachner's, and the present form are examples of the same species, the latitude must be very wide indeed.

PLATE XIV.

Morrhua macrocephala, reduced sketch of the specimen obtained at the mouth of the Thames, 1879.

MOLLUSCA OF H.M.S. 'CHALLENGER' EXPEDITION.

IV. Trochidæ continued, viz. the Genera *Basilissa* and *Trochus*, and the Turbinidæ, viz. the Genus *Turbo*. By the Rev. R. Boog Watson, B.A., F.L.S., &c.

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[Read June 5, 1879.]

The *Basilissa oxytropis* which follows did not present itself in time to be included in the previous list.

Of the *Trochus* group the Margaritas are many of them remarkable for beauty and for form.

The Turbos are very few; but one is of extraordinary beauty.

All the species now communicated are new. Some are from very deep water. All throw light on a marine zone not yet familiar. The list of known species presents no such features of interest as to call for its publication at present.

List of Genera and Species.

7. Basilissa oxytropis, *W.*

1. Trochus (Gibbula) glyptus, *W.*
2. T. (Ziziphinus) stirophorus, *W.*
3. T. (——) tiara, *W.*
4. T. (——) transenna, *W.*
5. T. (Margarita) brychius, *W.*
6. T. (——) charopus, *W.*
7. T. (——) pompholugotus, *W.*
8. T. (——) lima, *W.*
9. T. (——) æglëes, *W.*
10. Trochus (Margarita) clavatus, *W.*
11. T. (——) rhysus, *W.*
12. T. (——) infundibulum, *W.*
13. T. (——) pachychiles, *W.*
14. T. (——) azorensis, *W.*
15. T. (——) dnopherus, *W.*
16. T. (——?) scintillans, *W.*

1. Turbo (Calcar) henicus, *W.*
2. T. transenna, *W.*
3. T. (Collonia) indutus, *W.*

7. Basilissa oxytropis, *W.*

St. 344. April 3, 1876. Ascension Island. 420 fms. Hard ground. 2 young specimens.

Shell.—Small, high, conical, scalar, with a sharp, expressed carina at the periphery and a second carina above, angulating the whorls. *Sculpture.* There are a few close-set slight spirals on the edge of the flat base; there are many not close-set, flexuous, longitudinal ribs above the periphery, but on the base merely lines of growth. These ribs in crossing the upper carina form small sharp-pointed tubercles, of which there is also a trace on the lower carina. The superior *sinus* lies just above the upper carina, the basal sinus toward the middle of the base: both are well marked. The *apex* is small and flat, the smooth embryonic $1\frac{1}{4}$ whorl hardly rising at all. The *whorls* are of slow increase. The *pillar* is perpendicular, with a strong rounded sinus which corresponds to a swelling within the umbilicus. The *umbilicus* is not large, but deep, funnel-shaped, with a puckered sharp edge. In both specimens there are $5\frac{1}{2}$ whorls to a height of 0·05 and a breadth of 0·055.

This species slightly resembles *B. alta*, W., var. *oxytoma*, W., but is more depressed, the carina is sharper and is double, and the longitudinal ribs are very much stronger. Than *B. costulata*, W., this species is smaller, higher, more conical, and it is scalar; the whorls are more carinated above, and the peripheral carina is much more projecting; the apex is minuter and sharper, though the embryonic whorl is less raised, the base is smooth but for the marginal spirals; the umbilicus is smaller.

Before leaving this genus I may add that A. Adams's subgenus of *Forskällia* (*Gibbula*) is quite distinct. In it "the last whorl has a conspicuous *groove* at the periphery" according to his definition; but that is a spiral furrow formed by an impressed fold of the shell-wall in each successive whorl—not a sinus in the edge

of the mouth resembling that in the Pleurotomidæ, and differing from that of *Seguenzia* in the same way as the sinus of *Defrancia* differs from that of a typical *Pleurotoma*.

I may further say that I have lately, through the kindness of Dr. Gwyn Jeffreys, had an opportunity of examining a specimen of the *Solarium reticulatum*, Phil. (see 'Enumeratio,' II. 149, XXV. 6), a subfossil species from Calabria. It is quite certainly a *Basilissa*, and is intermediate between *B. costulata*, W., and *B. oxytropis*, W. From the former it differs in being much flatter on the base, sharper at the edge of the umbilicus and at the carina, and much more delicately sculptured. Than *B. oxytropis* it has a less expressed carina, and the whorls are not angulated in the middle.

1. Trochus (Gibbula) glyptus, *W.* (γλυπτὸς, carved.)

St. 164 a (2). June 13, 1874. Lat. 34° 13′ S., long. 151° 38′ E. Sydney. 410 fms. Grey ooze. 1 specimen.

Shell.—Like *T. magus*, L., but carinated, higher, less scalar, and much more delicately and richly sculptured. *Sculpture.* Spirals—a flat shoulder below the suture is followed by an angulation, on and below which is a double row of smallish, round, but pointed tubercles, which are remote from one another but run in pairs on the two rows. The tubercles in each row are connected by a slight rounded thread. On the second, third, and fourth whorls these rows coalesce into one; on the last whorl they are about 0·05 inch apart. At the periphery is a strong angulation bearing a sharp carina. About 0·05 inch above this is a spiral thread which, as well as the carina, is ornamented with delicate, sharp, laterally-compressed beads separated from one another by about twice their own size. Those on the upper spiral are rather the larger; the middle of the whorl for about 0·1 inch is bare. On the base there are five closely-beaded threads, of which the inmost and strongest defines the umbilicus. Between the outermost and the carina is a broad slightly sunken furrow. The carina meets the outer lip and appears above the suture. Longitudinals—the upper whorls are ribbed, but the ribbing gradually breaks into the double row of paired tubercles, and the link uniting the pairs in the two rows becomes very feeble. There are besides many distant, irregular, loose-skin-like puckerings which follow the lines of growth; they disappear on the spiral threads. The whole surface is further roughened by microscopic flexuous wrinklings. *Colour* yellowish white on the

thin calcareous layer overlying the nacre. *Spire* high, a little scalar. *Apex* small and sharp. *Whorls* 8, of regular increase, a little rounded, angulated at the carina, rather tumid on the base, with a wide umbilicus. *Suture* angulated and well defined, but a little filled up by the carina of the overlying whorl. *Mouth* (apparently) perpendicular, semioval. *Outer lip* well rounded. *Pillar-lip* a little bent over on the umbilicus, and then advancing rather straight towards the left, angulated and slightly toothed at the point of the base where the umbilical beaded thread joins it. *Umbilicus* a wide deep funnel with a deep spiral staircase at the junction of the whorls. H. 0·68. B. 0·72, least 0·61. Penultimate whorl 0·19. Mouth, height 0·32, breadth 0·32.

This beautiful species is unfortunately present in only one dead and chipped specimen. It is more like *T. magus*, L., than any other species I know, but is obviously very different in all details of form and sculpture. The name given to it is expressive of the singular beauty of its sculpture.

2. Trochus (Ziziphinus) stirophorus, *W.* (*στειροφόρος*, keeled.)

St. 24. Mar. 25, 1873. Culebra, St. Thomas, Danish West Indies. 390 fms. Mud. 1 specimen.

Shell.—Small, conical, scalar, inflated on the base; whorls angulated, with three strong carinas near the periphery, white over nacre. *Sculpture.* Spirals—at the periphery is a sharp flange-like carina; above this, about one third of the distance to the suture, is a second, almost equally strong and prominent, which forms a shoulder to the whorls. The space between this and the suture is divided pretty equally by two threads, the lower of which is feeble. On the upper whorls all of these are closely beaded, on the last whorl only the two highest are so. Below the carina is another remote strong thread, which meets the outer lip; within it is another, not quite so strong nor so distant, and occupying the space from this to the middle are five flat close-set threads, followed by three rather more separated and roughly beaded threads, the inmost of which, like a twisted cable, forms a sort of pillar with a chink between it and the sharp edge of the pillar-lip, and advances into a small tooth at the angle where it joins the outer lip on the base. Longitudinals—the whole surface is roughened by rather coarse oblique lines of growth, which on the upper whorls appear as oblique reticulating ribs. *Colour* white, with a translucent calcareous layer over nacre. *Spire* rather high, scalar. *Apex* a little flattened down and rounded, the

minute rounded embryonic $1\frac{1}{4}$ whorl scarcely rising above the level. *Whorls* 6, of rather rapid increase, with a narrow flat shelf below the suture, thence sloping flatly to the shoulder-carina, from which point the contour-line descends perpendicularly; the base is inflated at the edge and flattened in the middle. *Suture* deeply impressed between the narrow flat shelf below and the overhanging carina above. *Mouth* slightly oblique, but with a perpendicular pillar, round; nacreous within. *Outer* lip thin, transparently porcellanous on the edge, but thickened by nacre within. *Pillar-lip* perpendicular, rounded within the mouth, advancing to a sharp point in front, slightly reverted but not appressed, having a small open furrow and a minute umbilical chink behind it. H. 0·3. B. 0·26, least 0·22. Penultimate whorl 0·053. Mouth, height 0·14, breadth 0·14.

This species extremely resembles *T. occidentalis*, Migh., but is smaller, is broader in proportion, with a less high spire; the apex is not sharp and projecting, but flattened down and rounded: the whorls are much more scalar, and of more rapid increase; the base is more tumid on its outer edge and more rounded. The apex is ornamented with a minute and quite irregular inlaid work of angular depressions, parted by very narrow interrupted raised lines; whereas in that species the ornamentation is like honeycomb, with relatively large, nearly regular hexagonal pits and raised flat borders. This difference is shown in the woodcut. The threads on the base are approximate, not parted in the middle by a smooth zone, and the pillar-lip is not appressed as in that species; the outer lip, too, is thickened within by the layer of nacre.

Ornamentation of apex.
T. occidentalis. *T. stirophorus.*

3. TROCHUS (ZIZIPHINUS) TIARA, *W.* (From its high narrow form.)

St. 24. Mar. 25, 1873. Culebra, St. Thomas, Danish West Indies. 390 fms. Mud. 1 full-grown and 8 young specimens.

St. 56. May 29, 1873. Bermudas. 1075 fms. Grey ooze. 3 specimens.

Shell.—Small, conical, high-spired, flatly rounded on the base, sculptured, white, dull on the surface, with a bright nacreous gleam shining through. *Sculpture.* Spirals—on the upper part of the last whorl there are two rows of tubercles, the first and

weaker is close up to the suture; the second is a little lower than the middle, and its tubercles are strong. Of these there are on each row twenty to twenty-five; they are scarcely connected by a spiral thread. The periphery is sharply angulated and defined by an expressed and tubercled carina, the tubercles of which are hardly so strong as those of the second row above, which from its larger points projects quite as much as the carina. On the base there is an infracarinal furrow and three or four sharpish, equally parted, faintly tubercled, spiral threads, the inmost of which is most distinctly tubercled, and defines the umbilical depression. Longitudinals—the apical whorls, except the embryonic one, are crossed by high, sharp, slightly oblique ribs; but these on the later whorls break up into tubercles, between which on the different rows there is a slight irregular connexion by flattened ridges, which are oblique, interrupted, and on the base sinuous. Besides these the surface is roughened by minute wavy irregular lines of growth. *Colour* white, with a translucent layer of porcellanous glaze over brilliant pearly nacre. *Spire* high. *Apex* small, flattened, with the minute inflated $1\frac{1}{4}$ embryonic whorl rising a little exserted on one side. *Whorls* 7, projecting out squarely below the suture, flattened in the middle, protuberant at the second row of tubercles, and slightly contracted above the carina; at the carina sharply angulated. The base, which is flatly rounded, has a narrow flattish margin, and in the middle a slight umbilical depression, in the centre of which is a minute umbilical hole almost covered by the pillar-lip. *Suture* linear. *Mouth* scarcely oblique, and very slightly inclined out from the axial line, squarish, but rounded on the base and at the angles, a little broader than high, nacreous within. *Outer lip* not thin, with a slight callus just within it; it is slightly sinuated on the base at the outer corner. *Pillar-lip*, on leaving the body, bends over very flatly so as to cover the umbilicus, after which it curves round to the left; it has a very blunt tubercle in the middle, is a little reverted, and has a very slight furrow behind it. *Umbilicus* a small open depression leading into a minute central pore. The slopes of the depression are obliquely scored by the tubercles of the central basal thread. H. 0·22. B. 0·16, least 0·15. Penultimate whorl 0·05. Mouth, height 0·06, breadth 0·07.

This beautiful little shell offers some rather perplexing features; for the curves of growth on the base indicate a slight sinus toward its outer edge, which, indeed, is shown in the actual mouth-

edge, a peculiarity suggestive of the genus *Basilissa*; but there is not seldom in the Trochidæ a tendency to a backward curve of the lip-edge at that point; and in this species there does not exist the characteristic infrasutural sinus which would connect it with *Basilissa* or with *Seguenzia*, to which its tubercled pillar and closed umbilicus rather point.

Margarita carinata, A. Ad., from the Philippines, has some points of resemblance with this, but is obviously very different—markedly in the form of the umbilicus.

4. Trochus (Ziziphinus) transenna, *W.* (A lattice.)

St. 201. October 26, 1874. Lat. 7° 3′ N., long. 121° 55′ E. Philippines. 102 fms. Stones and gravel. 1 specimen.

Shell.—Small, conical, high, carinated, inflated on the base, thin, sculptured, yellowish with small ruddy spots. *Sculpture.* Spirals—close to the suture is a row of disconnected beads; between this and the carina are three rows of appressed beads, of which the highest is the weakest; these four rows are parted from one another by furrows, each of which is a little broader than the thread above it; the carina also consists of a row of appressed beads; it is stronger than the other threads both in breadth and height, and the furrow above it is a little broader and deeper than the rest. On the base are seven rows of appressed beads of nearly equal width and distance from one another: the first joins the outer lip, the central row twines up the pillar. These rows of beads make their appearance on the second whorl, and, on all the upper whorls, more than on the body-whorl, the carina is sharply expressed by a constriction above and below it. Longitudinals—the whole surface is crossed obliquely by not quite contiguous threads, which are almost as strong as the spirals. Between the threads are narrow, deep, long pits; each alternate thread is crowned by a bead at the suture. *Colour.* The surface is dull and rough, yellowish, sparsely spotted on the spirals with a ruddy brown, which is almost crimson on the infrasutural beads. *Spire* high and conical, the whorls being barely rounded. *Apex* small but flattened, the embryonic 1¼ whorl scarcely projecting. *Whorls* 7, of regular increase, almost flat, the body-whorl alone being slightly convex, rounded, and carinated at the periphery and tumid on the base, in the centre of which is the most minute umbilical chink. *Suture* deeply and squarely impressed below the carina. *Mouth* slightly

oblique, squarish, nacreous. *Outer lip* very thin, very slightly descending and drawn in a little horizontally at its junction with the body, and then well rounded in its whole sweep to the point of the pillar-lip, near which it is externally crenulated by the ends of the basal threads. *Pillar* is short, straight, slightly tubercled on its inner side, hardly toothed in front, and still less angulated at its junction with the outer lip. The pillar-lip is very thin, slightly excavated longitudinally, and reverted on the minute umbilicus, which it almost wholly conceals. Behind it is a very narrow furrow. H. 0·27. B. 0·22, least 0·2. Penultimate whorl 0·075. Mouth, breadth 0·117, height 0·125.

In form and details of sculpture this species is extremely like *T.* (*Thalotia*) *elisa*, Gould, from island of Capul, in the Philippines (B.M.), but is very obviously different.

5. TROCHUS (MARGARITA) BRYCHIUS, *W.* (*βρύχιος.*)

St. 152. February 11, 1874. Lat. 60° 52′ S., long. 80° 20′ E. 1300 miles S.E. of Kerguelen. 1260 fms. Diatomaceous ooze. 2 specimens.

Shell.—Globosely depressed, with a small high spire, very thin, rather opaque, rough, dull, and slightly iridescent. *Sculpture.* The whole surface looks as if a rough epidermis were gathered into close, minute, obliquely longitudinal puckerings, with stronger folds about 0·003 in. broad and 0·005 in. apart. These folds tend on the last whorl to disappear, except near the suture and toward the umbilicus. They are crossed by fourteen to sixteen fine round spiral threads, which at the crossing of each fold rise into knots. On the upper surface of the body-whorl they become very faint; there are four on the penultimate whorl, the first being remote from the upper suture, the last close to the lower suture. Besides these the surface is microscopically wrinkled spirally. *Colour* a dead slightly greyish white, which, toward the mouth, especially when wet, is faintly shot with a green and pink iridescence. *Spire* rather high, the earlier whorls being small and very much twisted out so as to rise above one another by almost their entire height. The *apex* is round and blunt, and terminates abruptly, but all the earlier whorls are stripped of their outer layer. *Whorls* 5, very round, of very regular but rather rapid increase. *Suture* deeply and sharply impressed. *Mouth* rather oblique, round, not descending, brilliantly iridescent within. *Outer lip* thin, turning down to meet the pillar-lip, and

carried across the short junction with the body by a thin nacreous callus, which is continued within and is, in fact, the completion of the whorl into a tube. *Inner lip* slightly thickened, curved, just barely reflected. *Umbilicus* wide and pervious, exposing all the whorls, and strongly cross-hatched within by the spiral and longitudinal threads. *Operculum* very thin, clear, and bright, with about eight faintly defined turns and marked with microscopic concentric lines. H. 0·64. B. 0·87, least 0·62. Penultimate whorl 0·18. Mouth, height 0·43, breadth 0·4.

This shell slightly recalls *Helix ericetorum*, Müll., but much more closely resembles some of the West-Indian land-operculates, such as *Aulopoma*. There is a *Margarita umbilicalis*, Broderip, which it is like, so far as one can judge from Chenu's figure With its continuous peristome it very much recalls a *Cyclostrema*, all the more so that it is less pearly within, less nacreous and more chalky, and less globosely conoidal than Margaritas usually are.

6. TROCHUS (MARGARITA) CHAROPUS, *W.* (χαροπὸς, light blue.)

St. 149 (9). Jan. 29, 1874. Lat. 49° 16′ S., long. 70° 12′ E. Kerguelen Islands, W. Christmas Harbour. 105 fms. 5 specimens.

Shell.—Globosely conical, like a *Cyclophorus*, thin, translucent, umbilicated, iridescent, banded, spirally studded with irregular interrupted, long, narrow, sharp tubercles. *Sculpture.* Of spiral threads there are from twenty-five to thirty-five, sharply projecting, rounded, and fine on the last whorl; of these, from three to seven are feebler than the rest; those on the base are continued within the mouth. The interstices are much broader than the threads. The whole surface is also fretted by microscopic spirals and stronger longitudinals which follow the oblique lines of growth. Of the threads, six to thirteen appear on the penultimate whorl; they begin with the second whorl, and there the longitudinals are rather disproportionately strong and regular. The embryonic apex is faintly but coarsely tubercled. *Colour* yellowish white, shot on the upperside with a dark iridescence; the spirals are black, clouded, and broken with oblique longitudinal streaks of white. The *spire* is high and turreted. The apex, porcellanous and scarcely iridescent, is small, high and mammillate, and consists of the one embryonic whorl, which is a little turned up on its side. *Whorls* 6, of gradual and regular increase, rounded, near the apex a little angulated by one of the spirals. *Suture* well marked, angulated,

but not sharply so. *Mouth* rather oblique, round, hardly angulated at the upper corner, not in the least descending, brilliantly iridescent within and showing the coloured spirals of the outside. *Outer lip* thin, slightly puckered at the spirals, a little thickened on the base. *Inner lip* thickened and reflected, especially at its junction with the body, where it almost covers the umbilicus. The *pillar* is much curved, and thins gradually out to its junction with the base. The *umbilicus* is large and funnel-shaped on the base, deep, but small further in, contracted by a spiral white pillar-pad, and more than half covered over by the pillar-lip. *Operculum* rather thin, horny, yellow, with ten to twelve very gradual turns, which are strongly defined by a thickened line; it is feebly marked with concentric and with radiating lines. H. 0·77. B. 0·78, least 0·66. Penultimate whorl 0·2. Mouth, height 0·4, breadth 0·4.

There is a *M. striata*, Leach (nec Brod.), which this resembles, but is very much more flattened and broader, and much more contracted in the spire.

Var. CÆRULEUS, *W.*

St. 151. Feb. 7, 1874. Heard Island. 75 fms. Mud. 1 specimen.

This differs from the type in having only four spiral threads above the periphery, while on the base below the peripheral thread the threads are also fewer, and are flattened out till they are barely parted by narrow lines of iridescent white. With the exception of these and the white umbilicus, the base is of an intense blue-black grey. The comparative absence of the spirals on the upper part of the whorls gives a flatness to the aspect of the shell below the suture, while the strength of the second and fourth spirals gives an angulation to the whorls that is apt to mislead the eye, the more so that the only specimen of this variety has the whole spire completely covered with Polyzoa. In spite, however, of its deceptive appearance, I am persuaded that this is only a variety of *T. charopus*, the more so that the markings on the embryonic whorl are identical.

In form this variety especially recalls *Margarita polaris*, Beck (Geneva Mus., Coll. Delessert), as also in its distant rather sharp spirals and half-covered umbilicus, but is more depressed on the base and flattened below the suture; the whorls are of much

more rapid increase, the spirals on the base are very much more numerous, and the shell is brilliant in polish and in colour.

7. Trochus (Margarita) pompholugotus, *W.* (πομφολυγωτὸς, bubble-shaped.)

St. 24. March 25, 1873. North of Culebra Island, St. Thomas, Danish West Indies. 390 fms. *Globigerina*-ooze, coral, shells. 1 specimen.

Shell.—Depressedly globose, with a low turreted spire, thin, opaque, chalky, rough, umbilicate. *Sculpture.* There are of spirals on the last whorl about forty, low, rounded, very unequal, some being very minute, one or two above the periphery stronger than the rest; the lowest of all is much the strongest, and defines the umbilicus, within which the whole sculpture increases in distinctness; on the penultimate whorl there are about twelve spirals fully stronger than on the last. The furrows are broader than the threads, but as they widen are occupied by a minute intermediate thread. Longitudinally these spirals and furrows are crossed by much finer and sharper oblique threads, which in general are much narrower than their interstices; but towards the mouth, where all the sculpture becomes feebler, these threads become extremely numerous and crowded. *Colour* yellowish chalky white over brilliant nacre. *Spire* not much elevated, but a little scalar. *Apex* eroded. *Whorls* 5, rounded, of rapid increase, inflated on the base. *Suture* impressed near the apex, while towards the mouth it becomes filled up, and is finally marginated, by the last whorl lapping up rather coarsely on the previous one. *Mouth* rather oblique, a little higher than it is broad, slightly flattened above, and a very little angulated at the junction of the outer lip to the body. *Lip* thin, a very little reflected on the umbilicus, porcellanous on the edge, with a very slight pearly marginal callus, which is continuous across the body, and nacreous within. *Umbilicus* large, funnel-shaped, quickly contracting, but leaving the whole inner spire visible. H. 0·38. B. 0·4, least 0·33. Penultimate whorl 0·1. Mouth, height 0·23, breadth 0·2.

Both in form and texture this species is extraordinarily like a depressed *Cyclostoma.* I have given it its name, in the absence of marked features, from its slight resemblance to a bubble. It has some resemblance to *T. lima*, W., when, as sometimes in that species, the sculpture is exceptionally obsolete; but the

sculpture is still very obviously different, and the form is globose, not, as in that species, high and conical.

8. Trochus (Margarita) lima, *W.*

St. 73. June 30, 1873. Lat. 38° 30′ N., long. 31° 14′ W. W. of Azores. 1000 fms. *Globigerina*-ooze. 5 specimens (1 full-grown).

St. 75. July 2, 1873. Lat. 38° 37′ N., long. 28° 30′ W. Fayal, Azores. 450 fms. Sand. 4 specimens, in spirit.

St. 78. July 10, 1873. Lat. 37° 24′ N., long. 25° 13′ W. St. Miguel, Azores. 1000 fms. *Globigerina*-ooze. 7 specimens (3 full-grown).

Shell.—Conical, with a broad and tumid base and a wide narrowed umbilicus; surface cross-hatched like a file; when fresh, translucent with a pearly sheen. *Sculpture.* Spirals—three to five slightly raised remotely beaded threads, of which one lies a little below the suture, one at the periphery forming a carina, of which the beads are much smaller and closer set, sometimes evanescent; one, with beads like the first, defines the umbilicus, within which there is a strong spiral ridge; and the whole surface is covered with fine rather sharp threads, whose partings are twice as broad as themselves. Of these finer spirals the one which meets the outer lip often rises into prominence and defines the base, while another above the carina sometimes stands out more strongly and more beaded than the rest. Longitudinals—the whole surface is close-set with these, which are crossed by the spirals, than which they are broader but less sharp, closer-set, and more irregular and interrupted, especially near the upper line of tubercles and near the umbilicus. *Colour* a bluish white when alive, with a translucent calcareous layer through which the nacre shines. *Spire* high, a little scalar. *Apex* small, a little flattened, with the embryonic $1\frac{1}{4}$ whorl barely projecting in the middle. *Whorls* 6–7; the last is of rapid increase, full rounded and a little tumid; the preceding ones are a little roundedly shouldered below the suture, flat on the contour, angulated at the carina, and slightly contracted into the suture; the apical whorls are simply rounded and longitudinally ribbed. *Suture* is linear, but strongly, not acutely defined by the perpendicular rise of the whorl above it and the slight sloping shoulder below. *Mouth* round, scarcely oblique, with a translucent porcellanous edge, and pearly within. *Outer lip* not descending, sharp, its inner edge is bevelled outwards at the expense of the

pearly layer. *Pillar-lip* bends over the umbilicus, is a little reverted, and expands into a tooth at the intra-umbilical ridge. *Umbilicus* funnel-shaped, wide, pervious, but narrowed within by the spiral ridge. *Operculum* of very many narrow whorls, which on their outer edge overlap as a narrow gleaming flange. H. 0·32. B. 0·32, least 0·28. Penultimate whorl 0·09. Mouth, height 0·18, breadth 0·18.

This is a much larger species than *T.* (*M.*) *cinereus*, Couth., from the North Atlantic, much higher, much more conical, much more exquisitely sculptured, suture more impressed, base more tumid and not angulated at the edge, umbilicus larger.

Than *T.* (*M.*) *amabilis*, Jeffr., it is, of course, still larger, less conical, less angulated, the sutural impression is not like a rounded gouged-out line as it is there, the base is not flattened, and the whole style of sculpture is totally distinct.

The measurements given above are taken from an almost exceptionally fine specimen from St. 78.

9. TROCHUS (MARGARITA) ÆGLEËS, *W.* (ἀιγλήεις, beautiful.)

St. 24. Mar. 25, 1873. Culebra Island, St. Thomas, Danish West Indies. 390 fms. Mud. 5 grown and many young specimens.

Shell.—Broadly conical, high, with a very large umbilicus, ornamented with rows of tubercles, carinated. *Sculpture.* Spirals —there is a row of small round pointed tubercles a little below the suture. The carina is double, formed by two rather remote tubercled threads, the lower of which runs to the outer lip. Below this one is a broadish furrow and slightly beaded thread, which, towards the mouth, projects so as to become a third carina. The centre of the base has another slightly beaded thread; and another, formed of remote rounded tubercles, defines the umbilicus, within which is a very slight furrow and an ill-defined ridge. Longitudinals—the apical whorls are ribbed, but the ribs gradually break into the scarcely connected tubercles of the last whorl. The lines of growth are hardly perceptible, except on the base. *Colour* pure white when weathered, but apparently slightly brownish when fresh, with a pearly nacre below the thin calcareous surface-layer. *Spire* high, very slightly scalar. *Apex* sharp, minute, flattened on the one side, with the very small embryonic 1¼ whorl rising sharply on the other. *Whorls* 7, of regular increase; the last is small, from the large

part of it cut out by the umbilicus; they are flattened on the contour and slightly scalar. *Suture* linear, but strongly defined by the right-angled junction of the whorls. *Mouth* oblique, much inclined to the axial line, rectangularly rounded, the pillar and outer lip being parallel. *Outer lip* thin and broken, not descending. *Pillar-lip* shortly but flatly bent over the umbilicus, and here it is patulous and sinuated, it then advances in a straight line towards the base. It is toothed in the middle by a strongish spiral protuberance, at which point it projects; but from this to the junction with the base it is thin and retreats. *Umbilicus* very large, funnel-shaped, and pervious. H. 0·27. B. 0·3, least 0·25. Penultimate whorl 0·08. Mouth, height 0·1, breadth 0·15.

This very beautiful species is well defined by its exactly conical form and very large umbilicus, which cuts the whole body out of the inside of the last whorl, narrowing the base to an extraordinary extent. The young shells are excessively like those of *Trochus* (*Ziziphinus*) *tiara*, W., but are flatter, broader, and more umbilicated.

10. Trochus (Margarita) clavatus, W. (*clavus*, a nail.)

St. 24. Mar. 25, 1873. Culebra Island, St. Thomas, Danish West Indies. 390 fms. Mud. 8 specimens (none full-grown ?).

St. 120. Sept. 9, 1873. Lat. 8° 37′ S., long. 34° 28′ W. Pernambuco. 675 fms. Mud. 2 young specimens (?).

Shell.—Small, conical, with a high spire and a tumid base, a round mouth, and a deep umbilicus, and covered with sharp prickles. *Sculpture.* Spirals—there are several small threads, two of which, of equal strength and prominence, angulate the whorls—one at the basal contraction, the other about halfway up the whorl; on the base they are somewhat closer set. The outer lip does not meet the carinal thread, but the one below. Longitudinals—the whole surface is crossed by close-set, slightly oblique narrow laminæ, which, in crossing the spirals, rise into sharp vaulted prickles whose faces are turned towards the mouth. *Colour* white, with a pearly lustre. *Spire* very high. *Apex* minute, with the small embryonic $1\frac{1}{4}$ whorl rising from a minute flat. *Whorls* $6\frac{1}{4}$, angulated and narrow in the spire, but the last inflated and expanded. *Suture* deeply impressed, somewhat depressed, and very strongly defined. *Mouth* perpendicular, round, slightly pointed on the base, and angulated at the upper carina. *Outer lip* sharp, advancing far across the body towards the pillar-

lip. *Pillar-lip* depressed upon the umbilicus, then rounded and sinuated, slightly toothed at the point of the pillar. *Umbilicus* wide and deep, but internally narrowed. H. 0·17. B. 0·13, least 0·1. Penultimate whorl 0·03. Mouth, height 0·07, breadth 0·07.

The peculiarly high narrow spire and the vaulted prickles are very characteristic features of this species. When full-grown there would probably be an additional whorl, which would add a broad base to the high narrow spire. There seems to be some variation in the number of the spirals. I have put a query to the specimens from Pernambuco, because, though identical in other respects, the embryonic whorls are slightly larger and more tumid. The curves of the mouth-edge have some suspicion of an infrasutural sinus, and the form of the pillar is also suggestive of *Basilissa*, but the form of the mouth is wholly unlike that genus.

11. Trochus (Margarita) rhysus, *W.* (ῥυσὸς, wrinkled.)

St. II. Jan. 13, 1873. Lat. 38° 10′ N., long. 9° 14′ W. Setubal. 470 fms. *Globigerina*-ooze. 1 specimen (young).

St. 23. Mar. 15, 1873. Sombrero Island, St. Thomas, Danish West Indies. 450 fms. *Globigerina*-ooze. 1 specimen.

Shell.—Small, conical, scalar, with rounded base and large umbilicus, sculptured. *Sculpture.* Spirals—there is a double, tubercled carina, of which the basal one meets the outer lip; the upper and stronger angulates the whorl about two fifths from the base; less than one fifth from the suture is a shoulder formed by a row of stronger remoter tubercles scarcely connected by a thread. On the base are two feebly beaded threads, another strongly beaded defines the umbilicus, close within which lies another delicately and remotely beaded. Longitudinals—the top whorls are strongly ribbed, but further down these ribs break into tubercles and become disconnected; but traces of these longitudinals remain here and there. The lines of growth are very faint. *Colour* white, with a pearly lustre. *Spire* high, scalar. *Apex* not fine, rounded, with the inflated $1\frac{1}{4}$ embryonic whorl standing out prominently. *Whorls* 6, flat below the suture, angulated at the first spiral, flat on the contour, angulated at the second spiral, and contracted into the suture below. *Suture* acutely angulately impressed. *Mouth* round, angulated at the front of the pillar. *Pillar-lip* slowly and slightly bent over the umbilicus.

Umbilicus open, funnel-shaped, internally scored with minute longitudinal ribs. H. 0·25. B. 0·21, least 0·18. Penultimate whorl 0·05. Mouth, height 0·1, breadth 0·09.

The specimen from which I have described this is in bad condition; but the species is certainly distinct from any other known to me.

12. Trochus (Margarita) infundibulum, *W.*

St. 56. May 29, 1873. Bermudas. 1075 fms. Grey ooze. 2 specimens, not full-grown.

St. 146. Dec. 29, 1873. Lat. 46° 46′ S., long. 45° 31′ E. Marion Island. 1375 fms. Bot. temp. 1°·5 C. *Globigerina*-ooze. 5 specimens (3 with the animal in spirit).

Animal of a uniform light colour. *Foot* broad, bluntly pointed behind. *Appendages* 5, probably 6, large, between which the membrane above them is edged with many small ones.

Shell.—Conical, with a tumid base, carinated, umbilicated, thin, translucent, pearly. *Sculpture.* Spirals, on the upper whorls 2, on the body-whorl 7–8, pretty strong, but fine beaded threads. The first lies remote below the suture, and is sparsely ornamented by longitudinally produced, high and pointed, tubercles; it forms a shoulder on the whorl. The second projects strongly and sharply at the periphery and forms the carina; it and those below are delicately fretted with close-set small beads. The third, which meets the outer lip, lies within the contraction of the base. The last two are closer than the rest, which, however, are sometimes brought closer by the additional thread which appears among them. The one which defines the umbilicus is more sharply beaded than the rest. Longitudinals—below the suture and near the umbilicus the surface is sharply but delicately puckered, and these puckerings, strong in the early whorls, are in the later faintly continued across the whorls as lines of growth. *Colour* yellowish white, with a brilliant nacreous sheen shining through the thin superficial calcareous layer, which becomes more opaque in drying. *Spire* high, scalar. *Apex* minute, flattened, with the minute bulbous embryonic $1\frac{1}{4}$ whorl projecting on one side. *Whorls* 8, of rapid increase, rounded, but angulated by the projection of the spirals, very tumid on the base. *Suture* linear, but strongly defined by the contraction of the suprajacent whorl and the flat shoulder of the one below. *Mouth* very slightly oblique, round, but on the pillar flattened, and at the

point of it angulated slightly; nacreous within; across the body there is no pad, but the shell is eroded, which looks like a thin callus. *Outer lip* thin, not descending. *Pillar-lip* slightly patulous, bending flatly over the umbilicus, and then advancing in a straight line to the point of the pillar, where it is slightly angulated just where the beaded umbilical spiral ends. *Umbilicus* funnel-shaped, rather open, but a good deal contracted within, sharply scored with the lines of growth. *Operculum* yellow, horny, very thin, of 7 to 8 whorls. H. 0·81. B. 0·65, least 0·59. Penultimate whorl 0·2. Mouth, height 0·37, breadth 0·35.

This beautiful species, of very singular aspect, recalls in a very general way the form of *Turcica monilifera*, A.Ad., but differs from that in its rounded contours, strongly contracted suture, umbilicus, and straight untoothed pillar. There is a *Margarita aspecta*, A. Ad., which this species resembles in form, but that is less tumid, is carinated, its umbilicus is much smaller, the spirals are many more, and they are not tubercled.

The presence of this species at two such separate localities as Bermudas and Marion Island, between the Cape and Australia, is interesting.

13. Trochus (Margarita) pachychiles, *W.* (παχύχειλης, thick-lipped.)

St. 201. Oct. 26, 1874. Lat. 7° 3′ N., long. 121° 48′ E. Philippines. 102 fms. Stones and gravel. 1 specimen.

Shell.—Small, conical, with the last whorl tumid, especially toward the mouth, which is extremely oblique, with a thickened lip; carinate, widely umbilicate. *Sculpture.* Spirals—in the centre of the body-whorl is a strong carinal thread, which almost runs into the outer lip at its junction with the body, but just lies above it, and so stands out round the base of the whole earlier whorls; this thread is set with strong, sharp, remote tubercles, which become feebler and more crowded toward the mouth: halfway between the carina and the suture is another thread, set with feebler tubercles; these two threads only appear on the second regular whorl, but on the body-whorl, especially towards the mouth, many others make their appearance a little below the carina, and issuing from the junction of the outer lip is a feebler tubercled thread, defining the base. On the base are three strong closely-beaded threads, the inmost of which defines the umbilicus, within which is a finer beaded thread and, deep inside, a ridge.

Longitudinals—all the upper whorls are crossed by strong straight ribs, forming tubercles where they cross the spirals, and leaving deep square hollows between. Only on the penultimate whorl do these become oblique and feebler, till toward the mouth they are narrow, weak, crowded and broken. Besides these, the whole surface is roughened with small, coarse, irregular lines of growth. *Colour* dead white. *Spire* high and conical, but the tumidity of the last whorl, especially towards the mouth, greatly detracts from this; it is slightly scalar. *Apex* small. *Whorls* 6, of slow increase till the last, angular, projecting out squarely from the suture, flattened on the contour, and contracted below the carina; but the last whorl is rounded, tumid, and, toward the mouth, expanded. The base is rounded, but not inflated. *Suture* very deep and strong, from the overhanging of the carina above it. *Mouth* extremely oblique, perfectly round but for a slight flatness across the body and an angulation at the junction of outer lip and of the pillar-lip to the body; pearly within. *Outer lip* very slightly descending on its line of junction to the body-whorl, then in its sweep rising a little: it is scarcely angulated at the lower carina and at the point of the pillar, but it is a little sinuated at that part; it is thin on the edge, but is thickened within by a pretty strong pearly callus and outside by a slight rounded marginal varix. *Pillar-lip* is hollowed back into the pillar in a sinus, and is sharply reverted, so as to leave a minute but deep furrow behind it; this reversion ceases just before it reaches the umbilical thread, and forms a minute tooth at that point. *Umbilicus* wide and pervious, but narrowed within; its slope is scored with minute sharp curved laminæ, the remnants of the old edges of the pillar-lip sinus. H. 0·18. B. 0·27, least 0·17. Penultimate whorl 0·04. Mouth, height 0·1, breadth 0·1.

In general aspect this is very like *T.* (*Margarita*) *gemmulosa*, A. Ad., in the British Museum; but that species has the spire lower, the suture distinctly depressed, the sutural furrow is beset with close radiating striæ, the spiral threads are more numerous and crowded, the pointed tubercles on these are more frequent, and there is no varix on the outer lip. That last is a feature which gives a great peculiarity to this species; but the thickening and the patulousness of the lip are not sufficient to connect it with *Gaza*. The distinct umbilicus and the absence of a tooth narrowing the mouth separate it obviously from *Craspedotus*.

14. Trochus (Margarita) azorensis, *W.*

St. 75. July 2, 1873. Lat. 38° 37′ N., long. 28° 30′ W. Fayal, Azores. 450 fms. Sand. 1 specimen in spirit.

Animal.—Dark in colour. *Operculum* rather strong, dark horn-colour, of very many narrow whorls, which on the outside are flanged with a thin narrow over lying border.

Shell.—Small, strong, but not thick, conoidal, high, with rounded contours, slightly angulated, scalar, sculptured, whitish, with a slightly flattened base and a small umbilicus. *Sculpture.* Spirals—there are very many close, unequal, irregular small furrows, which are feebler on the base and strongest near the suture, which is marginated below by a narrow smooth line round the top of the whorls. In the centre of the base is an umbilical depression with spiral threads in the bottom, and within this a strong white porcellanous spiral cord, which almost closes the umbilicus. Longitudinals—the top of the whorls is gathered into broad rounded oblique puckers, which die out before reaching the suture or the base. Besides these, the whole surface, spiral furrows and all, is sharply scratched with very close and numerous lines of growth. *Colour* yellowish translucent white, with a dull all-pervading nacreous gleam. The strong cord which fills the umbilicus is white, as is also the apex. *Spire* high, scalar, the separate whorls being a good deal sunk into one another, as well as flattened below the suture. *Apex* small, rounded, the minute embryonic $1\frac{1}{4}$ whorl barely projecting. *Whorls* 6, of regular increase, slightly flattened below the suture, rounded on the contour, barely contracted round their base; the last is faintly angulated at the periphery, and not much rounded on the base. *Suture* strongly marked by the contraction of the whorl above and the margination below. *Mouth* oblique, round. *Outer lip* sharp but strong, porcellanous on the edge, brilliantly nacreous within; it descends very slightly. *Pillar-lip* thick, white, bent, nearly to the point of the pillar, over the umbilicus. It would be reverted but for the great thickness of the spiral pad, which comes twining up behind it out of the umbilicus, and out of which, at the point of the pillar, it forms a flat, triangular, tooth-like expansion. *Umbilicus* a minute spiral hole, which twists in between the overlying pillar-lip and the umbilical pad; the edge is corrugated with the old lines of the lip. H. 0·33.

B. 0·4, least 0·3. Penultimate whorl 0·1. Mouth, height 0·2, breadth 0·17.

This species somewhat resembles in form *T. tumidus*, Mont.; but, apart from differences of texture, colour, and sculpture, it is much less angulated and less broad on the base than that, and the upper whorls are more tumid and more immersed. *T. (M.) grœnlandicus*, Ch., it also resembles in form and size; but, apart from all differences of colour and sculpture, it is, than that, less conical, more scalar, the suture is much more impressed, and the whorls are more immersed. From *T. (M.) lima*, W., it differs in the whorls being much more tumid and the general form less conical. From *T. (M.) pompholugotus*, W., it differs in the last whorl being far less tumid and out of proportion with those which precede. In contrast with *T. (M.) dnopherus*, W., the pad on the pillar-lip is here rather on the outside, with the lip flattened out upon it, while in that species the thickening is on the inside, filling up the lip.

15. Trochus (Margarita) dnopherus, *W.* (δνοφερὸς, dusky.)

St. 122. Sept. 10, 1873. Lat. 9° 5′ to 9° 10′ S., long. 34° 49′ to 34° 53′ W. Off Pernambuco. 350 fms. Mud.

Shell.—Depressedly conical, rather strong, semitransparent, of a dark pearly iridescence. *Sculpture.* There are spiral ridges, strong, five above the base; the first is close to the suture and is exquisitely beaded from the middle of the second whorl; the beads are about thirty-five on the last, twenty-two on the penultimate whorl. The second ridge is remote from the first, and forms a shoulder to the whorls. The third, fourth, and fifth occupy the periphery, which is carinated by the fourth till close up to the mouth, when the fifth forms the carina. Four fine threads, of which the first is partially beaded, lie in the flat between the first and second ridge; two between the second and third; one between the third and fourth. Below the fifth ridge is a flat furrow narrower than the rest; below the furrow is a sixth ridge, slighter than the others; and then the base is closely covered with eleven spiral threads, which tend to become stronger and wider apart near the umbilicus. The first three ridges alone appear on the upper whorls. Longitudinally the whole surface is sharply scored by the lines of growth. *Colour* a ruddy brownish white, shot with a purple and green iridescence. *Spire* depressedly

scalar. *Apex* bluntly mammillated by the somewhat shapeless, round, largish, glassy, ruddy, embryonic whorl. *Whorls* 4½, of rather rapid increase. *Suture* rather faint. *Mouth* oblique, roundish, being slightly peaked above and a little angulated on the pillar. *Outer lip* sharp but not thin, brilliantly iridescent within. *Inner lip* very much thickened by a pearly pad, which is very thick below where it envelopes what might otherwise have been a tooth on the point of the pillar. The pad is thinner in the middle of the pillar, and thickens again at the junction with the body-whorl, where it thins out quickly. The lip here is very slightly reflected on the umbilicus. *Umbilicus* very small and contracted, not so much by the reflection of the inner lip as by the pillar being bent round to the right across it. *Operculum* very thin, yellow, horny, with about eleven very faintly defined turns. H. 0·28 in. B. 0·37, least 0·26. Penultimate whorl 0·08. Mouth, height 0·2, breadth 0·2.

This species has a close general resemblance to *Margarita obscura*, Couth., but that is smaller, of slower increase, has an open umbilicus, is very dull in colour, and the whole minute system of spirals is different and much fewer; the tubercled spiral in particular is the second, not the first as here, and is not close to the suture. Than *M. poculosa*, Gould, which it resembles in its style of spirals, this is more discoidal, especially is this more tabulated below the suture than that; the angulation here is on the upper, not on the lower part of the whorls, and in that the infrasutural thread is not beaded.

16. TROCHUS (MARGARITA ?) SCINTILLANS, *W.*

St. 24. Mar. 25, 1873. Culebra Island, St. Thomas, Danish West Indies. 390 fms. Mud. 5 young specimens.

St. 56. May 29, 1873. Bermudas. 1075 fms. *Globigerina*-ooze. 1 specimen.

Shell.—Small, thin, white, very depressedly conoidal, angulated, tumid on the base, umbilicated; mouth semioval. *Sculpture.* It is perfectly smooth but for some curved puckerings which radiate from the umbilicus but very soon die out; above the middle the body-whorl is roundly angulated. *Colour* pure white, with a transparent calcareous layer over brilliant fiery pearly nacre. *Spire* very flatly conical. *Apex* bluntly rounded, with a minute, hyaline, depressed embryonic tip. *Whorls* 4½, barely rounded. *Suture* slightly depressed. *Mouth* semioval. *Outer lip* thin,

barely angulated at the periphery. *Pillar-lip* straight, patulous, right-angled at its junction with the base. *Umbilicus* small. H. 0·14. B. 0·2, least 0·16. Penultimate whorl 0·025. Mouth, height 0·09, breadth 0·11.

The specimen from which I have described this is neither full-grown nor perfect, but the species is a very well-marked one. It is much more depressed and has the whorls less rounded than *T.* (*M.*) *nitens*, Jeffr. Than *T. helicinus*, Fabr., it is much more depressed, much more brilliantly nacreous, and the surface is much more polished, and the radiating puckers are much stronger.

I have put a query to *Margarita* as the group to which this should be attached, because it has not a rounded mouth; but there is no other group of *Trochus* to which it can so well be attached, and none of the characters by which *Margarita* is defined are very constant.

1. Turbo (Calcar) henicus, *W.* (ἑνικὸς, unique.)

St. 173. July 24, 1874. Lat. 19° 10′ S., long. 179° 40′ E. Matuka, Fiji. 315 fms. 3 specimens.

Shell.—Conical, high; whorls flattened, sculptured, with a spinose carina, below which the suture is deeply channelled, scarcely coloured. *Sculpture.* Spirals—below the suture is a flat shoulder, the edge of which is angulated and bordered by a row of largish, white separate beads; on the flat slope of the last whorl are six rows of smaller separate beads, the highest row being the largest; they are not connected by a thread, and the intervals between the rows are about half the breadth of the beads. At the periphery is a sharp, expressed, stellate carina, the sharp, hollow, compressed spines of which are about twelve in number. Below the carina the whorls are somewhat constricted, and the contour-line here is perpendicular; on it are four rows of fine beads. The edge of the base is sharply angled and defined by a second smaller, sharp, expressed carina which meets the outer lip; it rises in from thirty to thirty-five vaulted scales, which toward the mouth become like spines. On the flat base are ten very regular rows of separate beads, which are a little stronger toward the middle, and the outermost one of which tends to become scaly. The centre is occupied by a polished, slightly ridged, porcellanous pad. Longitudinals—below the suture and between the beads there are many irregular puckerings following the lines of growth. *Colour* a light yellowish ruddy tinge, the base paler than the

upper part; the beads are white, and the porcellanous pad round the pillar is dead white, with more of translucency towards the centre; the pillar has a slight ruddy tinge. *Spire* high, perfectly conical. *Apex* round, the minute embryonic whorl being completely flattened down. The first three whorls are only radiatingly ribbed. On the fourth the highest row of beads begins, on the fifth the supracarinal row appears, and only on the sixth does the intermediate space become covered, previous to which the whorls have a nacreous gleam. *Whorls* 7 to 8, of very regular increase, flattened and angulated. *Suture* itself linear, marginated by the up-lap of the inferior whorl which covers the basal carina; it is very strongly channelled by the square contraction of the superior whorl beneath the stellate carina. *Mouth* oblique, round, angulated at the basal carina, with an exquisite soft pearly nacre within. *Outer lip* sharp, thin, with a broad porcellanous edge, and within this a broad flat nacreous callus; it is flat on the base. *Pillar-lip*, a broadly expanded porcellanous pad rises in the middle of the base, coils round the pillar, with a slightly swollen outer edge, and advances in front into a blunt round tooth. The edge of the lip is a broad, round, slightly ruddy pillar of nacre which unites itself with the labial callus. *Operculum* oval, rounded on the outer and straightish on the pillar contour, thick, with steep straight edges, and a very slight flange on its outer lower margin; its outer surface white, tubercled, rounded; its inner surface is flat, brown, lineated, with one large and very many minute whorls. H. 0·82. B. 1·0, least 0·81. Penultimate whorl 0·22. Mouth, height 0·36, breadth 0·39.

Perhaps *Turbo Philippiana*, A. Ad., or *T.* (*Guildfordia*) *rhodostoma*, Lam. (Geneva Museum), most closely resembles this species, which is, however, very distinct and much more beautiful. Strictly speaking, it belongs to none of the *Calcar* or *Astralium* groups, but touches several of these. The operculum is unlike that of *Stella*, of *Uvanilla*, or *Pomaulax*. The form of the shell is unlike *Pachypoma*, and neither shell nor operculum suit *Lithopoma*, *Imperator*, *Tubicanthus*, &c.

2. TURBO TRANSENNA, *W.* (*transenna*, a grating.)

St. 235. June 4, 1875. Lat. 34° 7′ N., long 138° 0′ W. Japan. 565 fms. Mud. 1 specimen.

Animal.—A pale uniform colour: the eyes are large and black, on short processes. There are no frontal lappets between the

tentacles, and though the forehead is thickened there and transversely wrinkled, there is no veil. The usual fringed membrane extends backwards above the foot-edge to the front of the operculum, but bears no th reads.

Shell.—Low, conical, round, with expanded base, sculptured, solid. *Sculpture.* The whole shell is cross-hatched by narrow, impressed, intersecting lines, which cross the whorls obliquely and not quite regularly nor uniformly, and which cut the surface into little diamonds resembling shagreen. *Colour* dirty rusty white. *Spire* rather low, but conical. *Whorls* of very rapid increase, apparently about 6. *Suture* linear, scarcely impressed. *Mouth* very oblique, round, nacreous to the very edge. *Outer lip* very slightly patulous, sharp on the edge, with a thick nacreous layer bevelled off to the edge above and in front, but on the base turned over and advancing in a rounded pad beyond the lip. *Pillar-lip* consists of a rounded mass of nacre, backed and above obscured by a considerable porcellanous deposit, which is widely but thinly spread out over the body so as to connect in a continuous sweep the outer and the pillar lips. It is distinctly impressed with the scale-like pattern of the underlying sculpture. Its edge is abrupt and chipped. *Operculum* thin, flat, highly porcellanous, with a translucent and slightly thinner central area on the outside. On the inside yellow, with many whorls, the nucleus nearly central, the suture well marked, and the last whorl less disproportionately large than usual. H. 0·87. B. 1·04, least 0·79. Penultimate whorl 0·29. Mouth, height 0·75, breadth 0·65.

The sculpture of this species is very peculiar. In form the shell is not unlike a *Diloma*, or something between *Litorina saxatilis* and a *Natica*. In texture the shell is thinner than the thickened lip suggests. The measurements of the mouth are not satisfactory, the outer edge of the pillar-lip being indefinite; if they be taken within the opening, they would give it as more truly round. The apex is eroded; and the whole aspect of the shell is so weathered that but for the presence of the animal I should have taken it for an old and spoiled specimen.

3. Turbo (Collonia) indutus, *W.*

St. 24. Mar. 25, 1873. Culebra Island, St. Thomas, Danish West Indies. 390 fms. 4 specimens.

Shell.—Small, conoidal, high, whorls tumid, base flattened;

colour white, glossy. *Sculpture.* The whole substance of the shell is faintly marked with remote spiral threads, and the surface is very faintly scratched with closer microscopic striæ. The whorls are bluntly angulated in the middle, and the last is so besides at the base below the periphery; this angulation meets the outer lip. The second and third whorls have two or three strong spiral threads. Longitudinals—there are very many, close, unequal, very oblique, hair-like lines of growth, of which the strongest rise in close-set, infrasutural puckerings, which on the third whorl resemble small beads. *Colour.* There is a glossy, thin, ivory-white calcareous coat over a brilliant pearly white layer. *Epidermis.* On the one living specimen there is an excessively thin tenacious brown layer, which may possibly be only an accidental deposit. *Spire* high, fine-pointed. *Apex* blunt, the smooth round embryonic $1\frac{1}{4}$ whorl scarcely projecting. *Whorls* 6, of rapid increase, tumid, the penultimate especially rising swollen out of the suture, the base is a little flattened. *Suture* linear, not impressed, a little coarse, slightly marginated by the up-lap of the succeeding on the preceding whorl and the slight tumidity caused by the infrasutural puckerings. *Mouth* very oblique, round, with a soft pearly nacre all round. *Outer lip* very slightly descending, thick, bevelled outwards to a sharp edge. *Pillar-lip.* There is a broad, thin, hyaline pad spread over the body and connecting the outer lip and the pillar, which is broad, thick, shallowly excavated, with a slight external median horizontal tooth or ridge; the edge is reverted and closely appressed. *Operculum* small, thin, calcareous, flat, convex on the inside, where it shows $7\frac{1}{2}$ whorls; the last whorl close to its end begins suddenly to enlarge. *Teeth* distinctively those of the family as represented by Lovén (see *Trochus* or *Phasianella*), there being endless rows of innumerable minute crooked uncini, with several (probably eleven) hooked and serrated central rasps, but in their confused dried-up condition it was impossible more minutely to identify them. H. 0·27. B. 0·25, least 0·23. Penultimate whorl 0·09. Mouth, height 0·13, breadth 0·12.

There is in the B.M. a species marked "*Collonia marginata*, Lam.," which in colour and form more than any other resembles this; but that is lirated, is rounded on the base, is toothed on the outer lip, and has not the angulation in the middle of the whorls.

On the Structure and Development of the Skull in the Urodelous Amphibia. By W. K. Parker, F.R.S., F.L.S., &c.

[Abstract.]

In a paper which has recently appeared in the 'Philosophical Transactions' (1877, part ii. pls. xxi.–xxix. pp. 529–597), I have laid down the foundations of the work of which the present communication is intended to be a piece of side wall. In that initial part the development of the skull of the Axolotl is traced through *nine* stages, from the unhatched embryo to large specimens that were losing their gills.

Then this series was perfected by the addition of the skull of *Amblystoma*—one of the Salamandrians into which a *Siredon*-larva is very apt to transform itself. But as *Amblystoma* does not show the fullest type of the skull of a "Caducibranch," I have therein added an account of that of *Seironota perspicillata*, a small kind of Newt of a high type. A small larva of that species served excellently as an intercalary stage between the *third* and *fourth* of the series of Axolotls: that, also, is added to the paper.

But, as is well known, the lowest "Perennibranchs" (such as *Proteus* and *Menobranchus*) are but a sort of *ametabolous larva* as compared with the adults of the higher kinds, and have their true morphological counterparts in the early larval stage of the highest kinds. These things being so, I thought it well to add an account of the skull of an adult *Proteus* to that paper.

The present paper (the materials for which I am indebted to my kind friends, Prof. Mivart and Mr. Tegetmeir) is simply a continuation of the one just spoken of. It does not exhaust my materials, much less the subject: it may therefore be considered as Part I. I have here given an account of the skull in several kinds: some only in the adult condition, but others with one or more larval stages.

The first type treated is the common Spotted Salamander (*Salamandra maculosa*), a viviparous species. Of this kind I have worked out embryos with large branchiæ, three-fourths ripe, ripe *cryptobranch* embryos, and the adult.

Then comes another good typical Caducibranch, namely, *Notophthalmus viridesens*; of this kind I had small larvæ and the adult.

The next is only in the adult stage; this is *Cynops pyrogaster*, one of the stoutest kinds, and whose skull is like the skull of a Crocodile, both in the strength and ruggedness of its architecture.

Then I have been able to follow this with a very different adult skull, namely, that of a sharp-toed Japanese Newt (*Onychodactylus*), which is, like the gigantic *Sieboldia*, a true Cryptobranch or hemimetabolous type.

After this comes the adult skull of *Taricha torosa*, which is *almost* typically Salamandrian, but falls off a little in its *palatines*, thus leading to those that follow, in which the palatines are greatly aborted, leaving the long rows of palatal teeth to attach themselves to the parasphenoid, as the *sphenoidal teeth*. These curious forms are here represented by the genera *Spelerpes* and *Desmognathus*. Of the latter I have only the adult; but of the former the adult of *Sperlepes rubra* and a larva, the youngest of *three* larvæ; the other two being of the species *S. salmonea*.

For details I must refer the reader to the main paper; but there are a few things that may be referred to here.

In the adults of the lowest "Perennibranchs" certain bones have appeared, namely, the premaxillaries, vomers, pterygopalatines, squamosals, frontals, parietals, and parasphenoid, besides *two* or *three* on the mandibular cartilage. These also are very early in their appearance in the larvæ of the metabolous types; afterwards, as they begin to change, other investing bones appear: the cartilaginous roof of the nose, which is absent in the lowest type, also makes its appearance, but always much later than the ear-capsule cartilage. These have a *new thing* which the Dipnoi (*Ceratodus*, *Lepidosiren*) do not possess, namely, the *stapes*. The Urodeles borrow a very primordial submucous bone from those generalized Fishes—the "pterygo-palatine," and also a cartilage from the Skates and the aberrant Sharks (*Notidanus*): this is the "antorbital," or *ethmo-palatine*.

In the Anura the "suspensorium" of the lower jaw lies so close, in infancy, to the ethmoidal region of the skull, that the ethmo-palatine cartilage and the pterygoid outgrowth of the suspensorium are not developed as distinct cartilages, but are merely conjugational *at first*.

But in the Urodeles these parts are perfectly independent; and in them the primordial "pterygo-palatine" bony plate (in the

metabolous types) is at first dentigerous, and then sends an edentulous process backwards; the bone cuts off this latter process, and then the two pieces become diversely applied to the skull proper. Tho tooth-bearing part, directly behind the corresponding vomer, either grows directly outwards beneath the ethmo-palatine cartilage or directly backwards beneath the *basis cranii*.

The latter condition is seen generally in Salamanders and Newts, which have a long dentigerous submesial palatine; the former modification is seen in *Amblystoma*; but in *Sperlepes* and *Desmognathus* we have these two modes combined. The edentulous bone applies itself to the pterygoid process of the suspensorium and to the inside of the body of the suspensorium (quadrate region).

In the Anura the pterygo-palatine cartilages are developed as one, and only become segmented rarely, as in *Bufo vulgaris*; but the bones are always developed independently, and not by the breaking-up of a simple primordial pterygo-palatine plate.

The transformations of the Anura are carried on in the plastic larva and *young* to a greater extent than in the Urodela.

In the Anura the opercular ray of the mandibular pier (the "spiracular cartilage" of the Shark) becomes the annulus tympanus, and a late-appearing hyomandibular becomes, by transformation, the columella auris.

In the Urodela the hyomandibular only occurs in the lower types; it is suppressed in the "Metabola" or Caducibranchs.

But some of these have a *pseudo-columella*, not lying under the facial or seventh nerve, as any part of the hyoid arch must, but *over* it, in the opercular skin. This spiraculo-stapedial bar (seen in *Menopoma*, *Spelerpes*, and *Desmognathus*) is of great interest, as showing how little *function* is to be trusted in morphology.

There have not been wanting anatomists who, failing from deficient embryological knowledge to see to the meaning of this or that part, have trusted to *teleological* explanations; but teleological science, belonging to another category of research and of thought, thus used, becomes a misleading light—an *ignis fatuus*.

On a Remarkably Branched *Syllis*, dredged by H.M.S. 'Challenger.' By W. C. M'Intosh, LL.D., F.R.S., F.L.S.

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[Read June 19, 1879.]

When, in the summer of 1878, Sir Wyville Thomson wrote me, inquiring if I knew of any branched annelid, I believe that the substance of the knowledge then extant was expressed when I mentioned that, though familiar with budding in such Turbellarians as *Catenula*, with the propagation by division in *Nais proboscidea* and *Chætogaster*, as well as the more complex condition in *Autolytus*, *Myrianida*, and *Filigrana*, I could not say that I had seen or read of a well-marked case of the kind. The subsequent arrival of a Hexactinellid sponge containing the annelids, and the various slides with mounted specimens, placed all doubts at rest; and, at Prof. Sir Wyville Thomson's request, I now make a note on this remarkable form. Unfortunately, the annelid was not observed till the return of the Expedition, and after immersion in spirit.

The Hexactinellid sponge was dredged at Station 209, in 95 fathoms, near Zebu, one of the Philippines, on greyish muddy ground, celebrated for the abundance of *Euplectellæ* and other remarkable sponges of the kind. Besides the *Syllis* the sponge was tenanted (as in *Euplectella*) by a small member of the Polynoidæ, which will be described in due time.

The Syllidian (*Syllis ramosa*) is located for the most part in the basal canals of the sponge, above the "wisp." In this region masses of the annelid, about a quarter of an inch in diameter, occur, and a multitude of branches pass into the smaller canals adjoining. Two of such masses are especially conspicuous. The intricate manner in which the branches are arranged makes it a very difficult matter to dissect them out, especially when the friability of the annelid and the sharp spicules of the sponge are taken into account. Even after removal from the sponge it is a laborious operation to unravel them without frequent rupture.

The masses and their numerous branches, as well as the isolated portions, consist of a *Syllis*-like annelid of the thickness of common sewing-thread. No head can be observed either in the parent-stock, amongst the masses, or in the canals elsewhere, so

that they must either be very few, only occasionally developed, or by some means have been swept off, as it is hard to believe that they are entirely absent. The latter, however, must be the condition in some of the examples (unless we are to suppose that all are connected with a single head), which, therefore, would appear to derive nourishment at the open end; yet, in many, the aperture rapidly develops a bud, which nearly closes it. If, in life, there are many examples with such open ends, then the whole series branching from them presents an analogous condition to that of very elementary animals, the food being swept in with the sea-water to traverse the moniliform nutritive canal throughout the organism.

The body of the animal stretches, from any of the broken ends, of a nearly uniform diameter for a considerable distance, the numerous narrow segments being distinctly marked, and each furnished laterally with well-formed feet. The latter have dorsally a long, and often gracefully curved, cirrus, composed of a variable number of segments, since injury and reparation constantly occur. The longer cirri have about twenty-six segments, and all the organs are gently tapered from base to apex. Beneath, and confluent with, the base of the cirrus is the somewhat conical setigerous region, which has a few simple bristles, with a stout and slightly curved shaft, the dilated distal portion having the simple terminal process apparently ankylosed to it. This modification of the bristle is peculiar. A single stout spine supports the setigerous region, and, as usual, its point passes to the upper border. The ventral cirrus is broad and short, its tip being within the line of the former division.

The body of the annelid appears to have a furor for budding—laterally, terminally, and wherever a broken surface occurs. The young buds remain slender till they have reached a considerable length, and into each a diverticulum of the alimentary canal of the parent enters. These buds, on attaining a certain size, by-and-by give off other buds, so that the whole has a remarkably branched condition. The tail of the bud (*i. e.* its distal point) is early formed, and soon becomes furnished with two long cirri. Indeed it would seem that in such a case the tail and the anus were more useful than the head, the eyes, and the finished buccal and pharyngeal apparatus.

The number of buds seems to be indefinite, the data at present being insufficient to enable me to fix a limit. Some of the larger

fragments show nine or ten buds, yet they are evidently far from being complete. The absence of a head leaves great uncertainty on the latter point; and if it existed at all, it could only have been in the siliceous stem of the sponge, which had been torn off.

Two female buds were found. One of these is still attached by its pedicle of four segments to the parent-stock. These intermediate segments somewhat resemble those of ordinary buds, only they are more slender. All have rudimentary lateral cirri and setigerous processes. The diverticulum of the alimentary canal proceeds from the main trunk in the ordinary way, passes through the anterior segments of the bud, and becomes lost in the opacity caused by the ova. The head of the bud is bilobate, and furnished dorsally with a large reddish-brown eye on each side, and a still larger pair, of similar shape (somewhat circular) and colour, on the ventral surface. These eyes, while useful for both dorsal and ventral vision, approach so near the margins that they are also available for lateral sight. The head terminates laterally in two short cirri and a setigerous process furnished with a spine.

The body of the female bud is somewhat fusiform, gradually increasing in diameter till full bread this attained, and, after a nearly cylindrical region, diminishing towards the tail, though to a less degree than anteriorly. The entire body, from the middle of the second segment backward, as well as the bases of the feet, is filled with ova, which show germinal vesicle and spot. The anterior segments are provided with bristles of the same type as the parent-stock, only the terminal appendage is more differentiated. None of the long simple bristles are apparent in this fragmentary example.

Exactly opposite the point from which the pedicle of the foregoing bud sprang is another small one, consisting of upward of a dozen segments. Moreover, in the same specimen, a pair of young buds occur opposite each other. In these cases the segment of the intestine of the parent-stock, from which the diverticulum proceeds, is shorter than the rest. It would seem that the bud arises opposite a foot, and there is no evidence that it ever springs between two (successive) feet. The shortening of the intestinal segment may be due to the appropriation of the substance of both it and the body-wall in the production of the new bud.

A free female bud, again, occurred in one of the basal canals of

the sponge. It closely agrees with the description of the foregoing specimen, except in the larger garnet-tinted eyes, and the presence of beautiful tufts of long simple bristles in each foot. Its length is about 9 millims., and its breadth, including the latter, rather more than 2 millims. There are twenty-nine segments, but the condition of the tail is open to doubt. Dorsally each segment has a slender and distinctly jointed cirrus. Beneath the foregoing, is a dense tuft of long, translucent, simple bristles, with broad flattened tips after the fashion of the straight Roman swords, but marked at the tip by two peculiar longitudinal processes, and sometimes the end assumes a fimbriated appearance. The setigerous region beneath is short and conical, having superiorly the spine and inferiorly the bristles, which differ from those of the parent-stock in showing a more evident differentiation at the junction of the terminal process. Ventrally is a tongue-shaped cirrus, which nearly reaches the tip of the setigerous region. The entire body is filled with ova, which likewise occupy the feet almost to their tips, the first segment and the extremity of the tail (which is apparently in process of regeneration) alone being devoid of them. Some of the feet, indeed, assume a bulk four or five times larger than the others, from distention with ova. The latter apparently have embryos internally.

Amongst the tangled masses in the channels of the sponge is a fragment of the posterior end of a form which differs from either of the foregoing. The feet, which are well marked and long, have dorsally a slightly convex margin; ventrally the outline is also somewhat convex at the base, but curves upward toward the tip. A short cirrus of four or five segments extends from the extremity of the dorsal margin, while beneath it is a dense tuft of long, straight, sword-shaped translucent bristles, similar to those described in the female bud. A flat papilla, about the middle of the bristle-bundle, shows that part of the foot to which the tip of the slender supporting spine proceeds. This slender spine diverges upward from the side of the stronger inferior one, the arrangement of the parts indicating that the foregoing tuft of simple bristles is of less morphological value than the others. A somewhat lanceolate process occurs at the ventral margin of the foot, and apparently corresponds to the setigerous division. It is supported by the stronger spine, and bears two or three bristles with simple terminal processes, similar

to those in the parent-stock. The body contains a large number of granules, and also masses of what appear to have been fully formed spermatozoa. Whether this is the male of the above form, or another, is, of course, an open question; but the bristles certainly correspond.

On Recent Species of *Heteropora*. By George Busk, F.R.S., F.L.S.

[Read June 19, 1879.]

(Plate XV.)

In the June number of the 'Journal of the Royal Microscopical Society,' Mr. W. Waters, F.G.S., has described a species of *Heteropora* from the seas of Japan to which he has given the name of *H. pelliculata*; he also mentions a second species from Australia under the appellation of *Heteropora cervicornis*, considering it to be identical with the *Plethopora cervicornis* of M. d'Orbigny *.

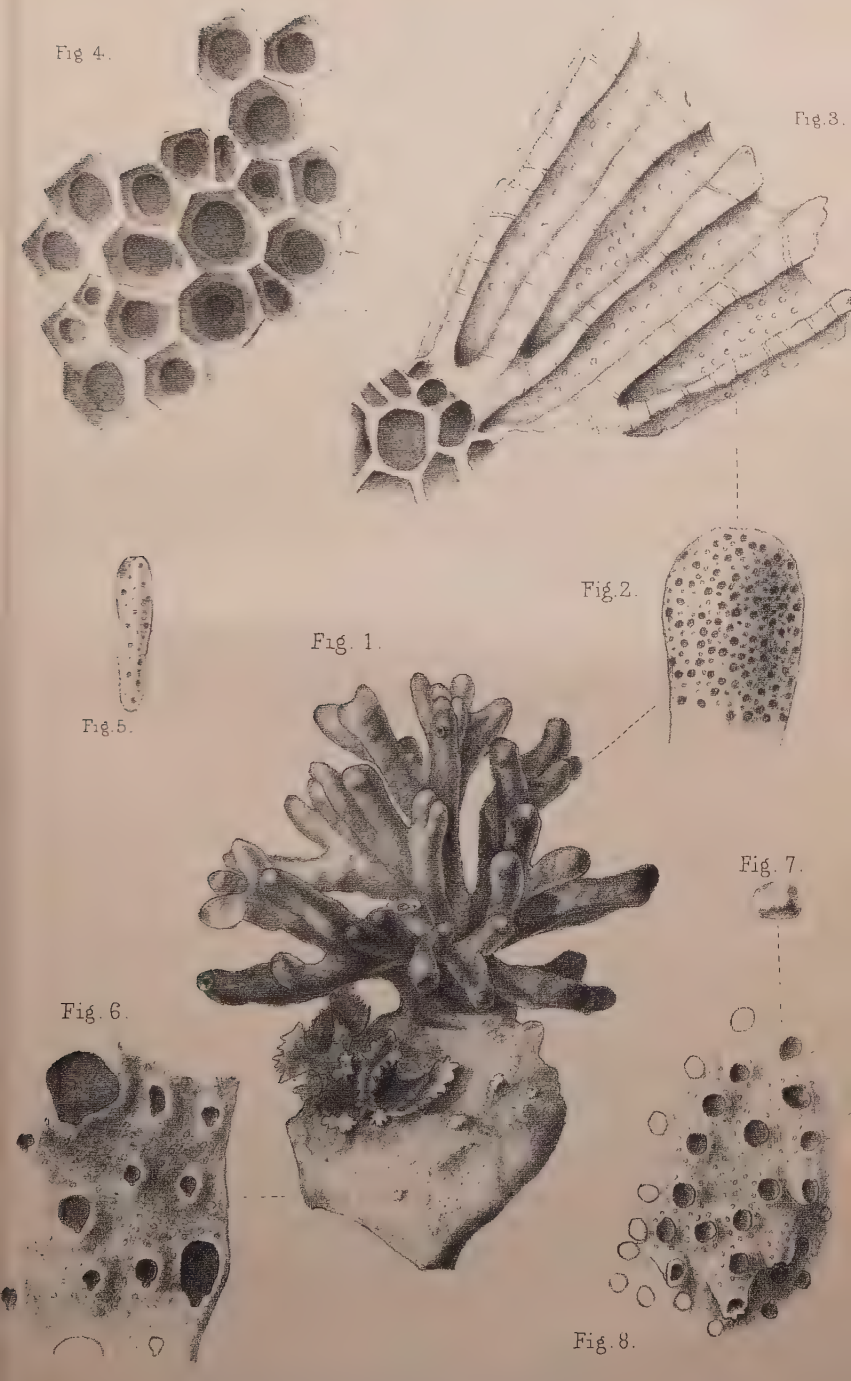
Till the appearance of Mr. Waters's interesting communication no species belonging to the genus seems to have been published. The occurrence, therefore, of the above two forms, belonging to a genus of which we had previously no species more recent than the Crag, and extending back to the Cretaceous period, is of particular interest.

My object in this brief communication is to indicate the existence at the present time of what may probably be a third species referable to the genus.

Some few years back Prof. Nicholson was good enough to furnish me with some very fine specimens of a recent *Heteropora* which he had received from New Zealand, and of which it was long since my intention to have furnished an account. This intention, however, has not hitherto been carried out; and I have thus been anticipated by Mr. Waters in the announcement of the fact of the present existence of the ancient genus *Heteropora*.

The New-Zealand species in most respects appears to bear a very strong resemblance to the Japanese form, and I am by no means satisfied that they are not specifically the same. As, however, there are one or two points in which, to judge from Mr.

* Pal. Française, pl. 799. figs. 4, 5.



J. Busk, del.

NEW SPECIES OF HETEROPORA.

Maclure & Macdonald

Waters's description and excellent figures, they do not quite agree, I have thought it might be useful to place on record a short description of the New-Zealand form in the 'Linnean Proceedings.'

In the absence of more complete acquaintance with Mr. Waters's form, I have provisionally designated the present one

HETEROPORA NEOZELANICA, n. sp.? (Pl. XV. figs. 1–4.)

Zoarium erect, composed of short divergent branches, springing from a short thick stem, and soon dividing once or twice dichotomously, and terminating in blunt rounded extremities. The diameter of the primary branches is about ·2 inch and of the terminal ones about ·1 to ·15 inch. The surface presents orifices of two kinds, though scarcely distinguishable in size. The larger ones, in the older parts of the growth, have a slightly raised peristome and are quite circular; the others (*cancelli*), disposed more or less regularly round these, generally to the number of 7 or 8, are more or less angular, and the border of the opening is never raised.

In the perfect state the surface, as in most Polyzoa, is covered with a thin chitinous pellicle, by which the cellular openings are more or less closed. In the New-Zealand species this epitheeal coat does not seem to become calcified or thickened, as in *H. pelliculata*, Waters, but always retains a delicate membranaceous character, and it is easily removed by caustic soda. Nor have I been able consequently to perceive the minute openings in the covering of the cancellar orifices described by Mr. Waters.

In sections the walls of the zoœcia and of the intermediate barren tubes or cancelli are perforated, as described and figured by Mr. Waters, by numerous infundibular pores, by which, as it would seem, facilities exist for the permeation of fluids throughout the entire zoarium. These pores and pore-canals are lined, like the zoœcia and cancelli, with a thin animal substance, which is readily dyed by any aniline colour &c., by which means the pore-canals are rendered beautifully distinct in thin sections.

The chief points of difference between mine and Mr. Waters's Japanese form would seem to consist:—(1) in the difference of habit—the branches in *H. pelliculata* appearing to be longer and more terete and to be occasionally connate, whilst in *H. neozelanica* they are short and not terete, expanding and never joined together; and (2) in the absence in *H. neozelanica* of the cal-

careous pellicle or epitheca, left after incineration in *H. pelliculata*. The internal structure, as regards the interzoœcial pores and canals, appears to be very much the same in both, except that in *H. neozelanica* there is no appearance in the walls of the zoœcia of the constrictions, giving them a beaded aspect, described and figured by Mr. Waters, and to which he is inclined to attribute the apparent constrictions of the zoœcia which are so common in most of the fossil species. In some of these, however, as I may take this opportunity of remarking, there are, besides the deceptive appearance of constrictions above referred to, distinct transverse dissepiments, which, as Mr. Waters remarks, are distinctly figured by M. J. Haime in his *H. pustulosa*. They are, however, equally evident in other fossil species.

DESCRIPTION OF PLATE XV.

Fig. 1. *Heteropora neozelanica*, natural size.
2. Portion of surface, magnified.
3. Transverse section, also highly magnified.
4. Portion of surface, showing openings, zoœcia, and cancelli, much enlarged.
5. A dead fragment of *Myriozoum* ——? resembling *Heteropora*.
6. Portion of surface of same, enlarged.
7. A doubtful form, resembling *Heteropora* of a globular form.
8. A small portion of the surface, magnified.

The two latter forms (figs. 5–8) are from the 'Challenger' collection.

An Analysis of the Species of Caddis-flies (*Phryganea*) described by Linnæus in his 'Fauna Suecica.' By Pastor H. D. J. Wallengren. Communicated (with Notes) by R. M'Lachlan, F.R.S., F.L.S.

The identification of the Swedish species of *Phryganea* described by Linnæus cannot fail to be of value to science; and I have therefore attempted to render them more clear. But it is not to be expected that all the enigmatical questions propounded in his descriptions can be answered; and I shall be glad if some of them, at least, are elucidated by the remarks that follow.

Phryganea phalænoides (No. 1481).—The identity of this with *Neuronia phalænoides* of succeeding authors is proved be-

yond doubt, notwithstanding the words "antennæ corpore dimidio breviores."

Phryganea reticulata (No. 1482).—The description has been applied to *Neuronia reticulata* of modern authors. This species is tolerably common in Sweden, but *N. clathrata*, Kol., is more so. The accepted idea may, however, be justifiable, for Linnæus says "inferiores subferrugineæ fascia nigra." It is nevertheless to be assumed that he had both species before him and confused them.

Ph. striata (No. 1483).—Recent authors have, on the authority of Hagen (Linnæa Entomologica, Band v. pp. 363–369), referred this to *Ph. striata* auct., but, as I think, unjustly. That Linnæus did not aim at this latter species is apparent by the words "alis *testaceis nervoso-striatis*," "alæ latæ *subtestaceæ* sive *fusco-testaceæ*." Without doubt he would have termed the wings of *striata* auct., "*cinereo-testaceæ*," as he did with *Ph. grandis*, and he would not have said "*alæ nervoso-striatæ*" if he had had *striata* auct. before him when writing his description. These words have a different sense to "*alæ reticulatæ*." The attention of the reader is directed by them to the *nervures* and not to the colour of the wings. The nervures in *striata* auct. are concealed in the pubescence, and do not strike the eye, as the words lead us to understand. It is to be remembered that Linnæus, in describing an animal, always points to the most salient character; and the nervures in *striata* auct. are *not* striking. Amongst the Swedish Caddis-flies, *Neuronia ruficrus* and *Agrypnia Pagetana* have "*alæ nervoso-striatæ*." That Linnæus did not intend the latter is evident by the words "alæ magnæ latæ," which are not applicable. Thus *Neuronia ruficrus* only can be the species described by him as *Ph. striata*, and Burmeister was right in his identification (Handbuch, ii. 2, p. 935). Nothing in the description is opposed to this; the "punctum album postice in ala superiore" is seen when the wings are closed. Only the words "facies Phalænæ majoris" appear not to accord with my supposition; but if "major" be understood in the sense of *Bombyx pavonia*, *quercus*, etc., it could neither agree with *striata* auct. nor with *ruficrus*. But Linnæus wished the reader to have in view some of his smaller *Phalænæ*, such as *Tortrix* and *Tinea*; and it must also be remembered that he, in his description of *Ph. reticulata*, says "*media*, statura Phalænæ;" and he desired, in the words quoted, to institute a comparison between the two. *N. ruficrus*, which is common in Southern and

Central Sweden, is larger than *reticulata*. If Linnæus had *striata* auct. in view, he would undoubtedly have said "magna," as he does in his description of *grandis*, next to which he would, moreover, have placed the species. *Neuronia ruficrus* should therefore take the name *N. striata*.

Phryganea grisea (No. 1484).—The intention of Linnæus has been misunderstood in referring the name to the *grisea* of almost all succeeding authors. If the latter were intended it is not explainable why no mention is made of the "fenestrate spot" and "anastomosal space," which are very evident in that species; and in connexion with this should be added the words "mediæ magnitudinis est," in comparison with the other species known to him. In the males of *grisea* auct. it is true that these markings are more obsolete than in the females, but very rarely are they obliterated altogether. The dark pterostigma is, moreover, but faintly indicated, whereas the *grisea* of Linnæus has a distinct "macula marginali nigra" on the anterior (inferior in regarding an unexpanded insect) margin. Moreover, in describing the *grisea* of authors, he would not have said "alæ superiores *griseæ*," but rather "alæ cinereo-testaceæ," or "subferrugineæ," as used elsewhere. He would not have said "corpus griseum," but "corpus fuscum" or "nigrum." Thus his description cannot concern *grisea* auct., but another species with a strongly-marked pterostigma; and the only Swedish species possessing this character is *Limnophilus stigma*, Curt. The wings of the Linnæan insect are "griseæ;" and the sense of this is to be learned from the description of *Ph. rhombica*, where he says "alæ subluteæ sive *griseæ*." *Ph. rhombica* never approaches *grisea* auct. in colour, but often resembles *L. stigma* in this respect, the wings of which are, moreover, "fusco obsolete nebulosæ," as is said; and the colour of the body is similar, as is also indicated by the words "alæ superiores (uti totum corpus) griseæ." The example in the Linnæan collection is therefore typical, bearing, as it does, the label "*grisea*" in Sir J. E. Smith's handwriting; and No. 749, in Linnæus's handwriting, corresponding to *grisea* in the 1st edition of the 'Fauna Suecica.' *Limnophilus stigma*, Curt., should thus take the name of *L. griseus*, L.

Ph. grandis (No. 1485).—There can be no question as to what Linnæus intended; but it is evident that he had not separated *striata* auct. (=*bipunctata*, Retz.) from *grandis* auct. In all

the old Swedish collections both species are mixed under "*grandis*;" but *grandis* auct. may continue to bear the name, the description agreeing. Both are common in Sweden, especially in "Scania."

PHRYGANEA RHOMBICA (No. 1486).—According to Mr. M'Lachlan *Limnophilus marmoratus*, Curt., and *L. subcentralis*, Brauer, exist in the Linnæan collection, but not *L. rhombicus* auct. The first-named bears the label "*rhombica*" in Sir J. E. Smith's handwriting, and the No. "741" in that of Linnæus, corresponding with the 1st edition of the 'Fauna Suecica.' Nothing in the description indicates that he had *subcentralis* before him when writing it; and it is, moreover, a very rare species in Sweden, of which I have as yet seen only three specimens. *L. marmoratus* has usually a very dark pterostigma, of which Linnæus makes no mention, nor does he allude to the dark irrorations so marked in the dorsal area of that species; and it cannot therefore be his *rhombica*. But it may be *rhombicus* auct., to which only the words "in medio alæ exteriores macula rhombica albida obliqua, et pone hanc alia albida vix notabilis—supra et pone maculam alarem aliquid fusci" will apply. The latter words evidently allude to the dark marks at the fenestrate spot as seen in *L. rhombicus* auct., which should continue to bear the name, notwithstanding that it is not represented in the Linnæan collection.

PH. BIMACULATA (No. 1487).—This, like many other Linnean species, has been misinterpreted. The name is commonly referred to *Neureclipsis bimaculata* auct., although the description says "non autem inter *minimas*," and the minute species known to Linnæus are compared by him with *Musca* or *Culex*. *N. bimaculata* auct. is not larger than *Ph. longicornis*, *azurea*, or *albifrons*, L.; and if he had intended it, he would have described it as "inter minimas" without the negation; and furthermore, concerning the double spot on the wings, he would have said "altera *supra* alteram" (perhaps inserting the word "oblique"), and not "altera *pone* alteram," as he does. With Linnæus the anterior margin of the wing is the "*margo inferior*," and the posterior (or inner) margin is the "margo exterior vel superior;" so that in describing the *Neureclipsis* he would have used "*supra*" and not "*pone*," as regards the spots, as he does in his other descriptions; for in *Neureclipsis* one spot is on the disk of the wing, and the other on the anterior margin only a little before the former obliquely

and not *behind* it in the Linnæan sense. Thus the *Neureclipsis* is not his species. What the latter really is should not be difficult to determine. He describes it as "non autem inter minimas;" and by these words all species so small as *Ph. longicornis* etc. are excluded; and the first word, "minor," is also opposed to the species intended by the foregoing descriptions, as, for example (*Ph. rhombica*), "Est hæc inter majusculas sui generis," and (*Ph. grisea*) "mediæ magnitudinis est." The Linnean species should therefore be larger than the "small" species (*P. longicornis, azurea*, &c.), but smaller than *Ph. rhombica* and *grisea*; and the wings should, furthermore, be "fuscæ," which excludes all pale species. All species of *Anabolia* and *Stenophylax* are also excluded, partly because they are ordinarily too large, partly because they have no "macula duplex flava, altera pone alteram." There remain only the dark species of *Limnophilus*, and of these only *L. bipunctatus* and *L. griseus* auct. With the former the words "macula duplex flava" will not agree, the anastomosal space being indistinct and scarcely paler than the ground-colour. *L. bipunctatus* is, moreover, too large, being of the size of *Ph. grisea* (*stigma* auct.), of which Linnæus says, "mediæ magnitudinis est;" the words "minor, non autem inter minimas" are thus not applicable to *L. bipunctatus*. Therefore only *L. griseus* auct. agrees with the description, it having the "fenestrate spot" and "anastomosal space" very distinct; these are the spots that Linnæus describes, and they are not unfrequently yellowish or yellow, as he says. This species also stands in the collections of the old Swedish entomologists as *Ph. bimaculata*, L., proving that such an application of the name had occurred to those who lived near the time of Linnæus, and who were partly his disciples (see also Zetterstedt, 'Insecta Lapponica,' p. 1062, who says, "sub nomine *Ph. bimaculata*, L., exempla hujus speciei mihi etiam communicata fuerunt"). Thus the example in the Linnean collection is typical (see M'Lachlan, 'Revision and Synopsis,' p. 87, footnote); and *bimaculata*, L., equals *Limnophilus griseus* auct. It could not possibly be *Neureclipsis bimaculata* auct., which, moreover, is not common in Sweden, whereas *L. griseus* auct. is very common.

PHRYGANEA FLAVILATERA (No. 1488).—This is an apocryphal insect, and no one has essayed a determination of it, other than that it may be *Sialis lutaria* auct. It should be sufficient, by pointing out the words "thoracis lateribus flavis" in the descrip-

tion, to convince us that the author did not intend the *Sialis*, which he, moreover, probably describes as *Hemerobius lutarius* at p. 384 (No. 1513). His words, " Sedet alis deflexis uti Phalæna," clearly indicate the family to which it belongs. If used in comparison with all the foregoing species, they have special weight, for of the next following (*P. bicaudata*) is said " alæ incumbentes, non deflexis." The same may be said of the words " cauda simplex absque stylis prominulis," whereas the following species is indicated by "cauda duabus setis antenniformibus." It is therefore a true " *Phryganea* " and not a *Perla*. Its wings are described as " reticulatæ ; venis fuscis maxime reticulatis, præsertim ad margine exteriorem." The *colour* of the wings has thus some resemblance to that of *Ph. reticulata*, L. ; and the insect can be sought for neither amongst the *Limnophilidæ* nor the *Leptoceridæ*, for there is no species in these families with such a colour. Only the *Hydropsychidæ* and *Rhyacophilidæ* remain, and it is possible that in one of these the species may be found. The families have the " margo exterior " (inner margin) " admodum dilatatus " in comparison with the others, and some of them by day are more tranquil than is usual, thus justifying the use of the words " ubi sedet tranquilla." The words " os duobus denticulis et quatuor a palpis " point to a *Hydropsyche* and not to a *Rhyacophila*, which the strong fuscous reticulation also makes clear. The denticulation of the mouth and palpi is such that it may not have escaped the notice of such an acute observer as Linnæus. His words probably refer to the maxillary processes and the processes of the labial palpi ; but the words " antennæ corpore dimidio breviores " seem to nullify this supposition. The antennæ in *Hydropsyche* are seldom longer than the wings, but they are always more than half the length of the body. They may have been broken in Linnæus's type, as they were in that of his *Ph. phalænoides*, of which he equally says, " antennæ corpore dimidio breviores." I am therefore convinced that he did intend a *Hydropsyche* ; and among the Swedish species only *H. instabilis* auct. could be intended, for the description agrees tolerably well with it. The wings are cinereous, their fuscous reticulation is especially strong toward the inner margin, and the thorax is yellowish at the sides.

Phryganea bicaudata (No. 1489) is a *Perla*, as is well known.

Ph. nigra (No. 1490) is *Mystacides atra*, Pict., as I have already hown in the Öfversigt af K. Vet.-Ak. Förhandl. 1870, p. 151.

Phryganea azurea (No. 1491) is *Mystacides nigra*, Pict.; and Ph. longicornis (No. 1492) is *M. quadrifasciata*, F.

Ph. filosa (No. 1493).—This cannot be *Œcetis ochracea* auct. (=*Ph. hectica*, Zett.), which is rare in Sweden, and has not the wings "flavescentes," but "flavæ vel flavidæ" according to the Linnæan terminology. The old Swedish entomologists have named the latter species "*hectica*," and under this name it stands in their collections. *Leptocerus tineoides* (Scopoli), Brauer, is, on the contrary, assumed by them to be the *filosa* of Linnæus; but his description is too brief. The "alæ cylindrico-incumbentes" suggest a *Molanna*; but the "antennæ corpore triplo longiores" will not agree.

Ph. Wæneri (No. 1494) is *Tinodes luridus*, Curt., as I have already shown.

Ph. albifrons (No. 1495). All authors agree as to this.

Ph. bilineata (No.1496) is *Mystacides bifasciata*, Pict., as Mr. M'Lachlan has shown (*Leptocerus bilineatus*) in his 'Revision and Synopsis,' p. 308.

Ph. ciliaris (No. 1497) is *Notidobia ciliaris* auct. as accepted.

Ph. umbrosa (No. 1498).—Mr. M'Lachlan ('Revision and Synopsis,' p. 399) believes that this was a collective name for various species belonging to the genus *Polycentropus* and allies. The *diagnosis* undoubtedly refers to *P. flavomaculatus* auct., from the words "alæ lutescenti-nebulosis;" but the *description* refers to *Holocentropus dubius*, Rambur, for Linnæus there says "alæ irroratæ glauco-fuscescente colore." Both occur in Sweden.

Ph. nebulosa (No. 1499) and fusca (No. 1500) belong to the *Perlidæ*, as is well known.

Ph. minuta (No. 1501) is probably *Beræodes minuta* auct.; but I am not yet fully convinced.

Ph. flava (No. 1502) cannot be *Limnophilus vittatus*, F., for Linnæus does not mention the fuscous vitta in the wings; but it may be *L. centralis*, Curt., as Swedish entomologists have assumed. The words "flava, alis flavo-reticulatis" agree with no other Swedish species.

Ph. saltatrix (No. 1503) is not a true "*Phryganea*," and cannot be a *Chermes* or *Psylla*, to which the words "adeoque non *Chermes*"

are opposed. Hagen has conjectured that it may be a *Psocus*; and the words "antennæ, lente inspectæ villosæ apparent; os ut in reliquis cum palpis" favour this opinion; but the species is not to be settled with certainty. I think it may be *Stenopsocus immaculatus*, Steph.

Linnæus has furthermore described an insect as *Tinea Robertella* (No. 1394) that cannot be Lepidopterous, for neither in Sweden nor in Europe is there to be found a species of that order to which the description will apply. It may have been a "*Phryganea*" that Linnæus had before him, and we know that he often made a comparison between the *Phryganeæ* and Lepidoptera. It may therefore not be strange if we find him describing a "*Phryganea*" as a "*Tinea.*" The words "antennæ longissimæ" may therefore signify some species of *Leptoceridæ*. The *Tineæ* (*Degeerella*, *Swammerdamella*, &c.), amongst which he places the species, have a striking resemblance to this family. The words "alæ fuscæ seu nigræ, vix manifeste cinereo-inauratæ, macula alba ad angulum ani" are only applicable to *Leptocerus aterrimus*, Steph., or *L. dissimilis*, Steph.; but the words "antennis albis" do not agree. However, the Linnæan terminology is not as accurate as that of the present day, and the antennæ of *L. dissimilis* appear to be white and unicolorous if viewed in a certain light. I am convinced that this is the Linnæan species; the size is the same, and the words "alæ vix manifeste cinereo-auratæ" indicate the pale brown iridescent pubescence of the wings.

Notes by R. M'Lachlan.

It was, I think, partly at my suggestion that my valued correspondent Pastor Wallengren undertook an analysis of the Swedish Trichopterous insects described by his great compatriot. He had already casually alluded to several species in his notes on those described by Zetterstedt (*cf.* 'Öfversigt af K. Vet.-Akad. Förhandlingar,' 1870, No. 3). The foregoing notes have especial reference to the nomenclature adopted by me in my 'Revision and Synopsis of European Trichoptera,' now completed as far as the Linnæan species are concerned. In this work I have generally adopted Pastor Wallengren's already published views, on the principle that a Swedish entomologist should be the best able to elucidate the Linnæan species; moreover I satisfied myself that these views were sufficiently borne out by the original descriptions;

and I propose to pass over his present remarks without comment, so far as regards them. But in a few other instances the results arrived at appear to be open to question, and they bear also the inconvenience of upsetting widely and generally adopted nomenclature, which should be avoided so far as is consistent with the due recognition of the rule of priority. In these few instances I do not feel justified in abandoning existing nomenclature; but on points of this nature there must exist differences of opinion, and other workers may feel inclined to regard the evidence in a different light. Pastor Wallengren does not allude to the 'Systema Naturæ,' ed. xii., in which Linné adds references wanting in the 'Fauna;' and it should be noted that still other references exist in MS. in his own annotated copy of the 'Systema' in the Library of the Linnean Society.

The Linnæan collection affords very little evidence. There are in it a moderate number of Trichoptera, but only two or three bear labels in Linné's hand: and, as is usual, there is much uncertainty as to whether they are now on the specimens to which they were originally attached.

Phryganea striata (No. 1483).—Up to the year 1851 no author had separated by sure *structural* characters the two species which now generally bear the names of *Ph. grandis*, L., and *striata*, L. In that year Hagen demonstrated most clearly the existence of two very distinct species, to the second of which he applied the name *striata*, retaining that of *grandis* for the first, in which he has been generally followed. Considering the great outward resemblance of these two species, and that Linné was unaware of the importance of the structural characters in Trichoptera, it has always been with me doubtful that he could possibly have separated the two; and it is rendered still more doubtful in my mind from the interposition of a small and very different insect between them (*cf.* my 'Revision and Synopsis,' p. 24). Still there does exist (although Hagen states the contrary) in Linné's collection a ♀ of that which we now term *striata* bearing a label (No. 738) in Linné's hand: it is considerably rubbed, and in that condition is not opposed to the words of the description, and the objections stated by Pastor Wallengren are so far not well grounded. I find it impossible to accept the latter's views as to the identity of *striata* with *Neuronia ruficrus*. The word "subtestaceæ," even with the addition of "sive fuscæ,"

seems to me to render such a connexion most unlikely, whereas they are not opposed to the example in the collection, which also still shows the "punctum album" (the spot in the 6th apical cellule). Therefore, notwithstanding the objection I have taken to the application of the name *striata*, it may be that he really intended by it the insect now so called; and I would continue to so apply it instead of upsetting long existing nomenclature by transferring it to the species we know as *Neuronia ruficrus*. Hagen (*l. c.*) enters largely into the references in the 'Systema;' it should be added that Linné also cites (in MS.) "Scopoli, fig. 688" (from the rare and unpublished vol. of figures to that author's work), which appears to me quite unrecognizable.

PHRYGANEA GRISEA (No. 1484).—There exists in Linné's collection an insect bearing a label "No. 739" (corresponding to the 'Fauna,' ed. 1) in his hand, which is certainly not the *grisea* universally so called by authors. It is a small ♂ (similar in size to most of the Swedish specimens I have seen) of *Limnophilus stigma*, Curtis (*cf.* my 'Revision and Synopsis,' p. 58, footnote); and confessedly Pastor Wallengren's ideas appear to have at least a *primâ facie* appearance of being well grounded; such a change will, however, be little palatable to authors.

PH. BIMACULATA (No. 1487).—Pastor Wallengren would consider this as representing *Limnophilus griseus* of authors. I, on my part, hesitate to adopt his view. It appears to me that the words relating to the spots, "altera pone alteram," are applicable to the position of these markings in *Neureclipsis bimaculata* of authors. In effect the prepositions "pone" and "supra" would be equally correct; for the second spot is placed decidedly after or behind the first, although more towards the costal margin; and, moreover, the words "lunularis" (not quoted by Wallengren) and "flava" are more suitable to the *Neureclipsis* than to the *Limnophilus*. Nevertheless it is quite true that the insect in Linné's collection, referring to his *grisea*, is the latter (*cf.* my 'Revision and Synopsis,' p. 87, footnote). Supposing Pastor Wallengren's views be accepted, the *Neureclipsis* will take the specific name of *figurinensis*, Fabricius. Linné has added the following MS. citations:—"De Geer, Ins. ii. p. 568, tab. 15. fig. 5" (*Leptoceridæ*); "Schäff. Icon. tab. 109. figs. 3, 4" (probably *Limnophilus sparsus*), and "Geoff. Ins. ii. p. 248. no. 5" (*Leptocerus*).

Phryganea flavilatera (No. 1488).—Notwithstanding his elaborate argument, I scarcely think Pastor Wallengren would adopt this name as replacing (*Hydropsyche*) *instabilis*, and I confess myself unable to entirely follow him. It has been repeatedly suggested that Linné had *Sialis lutaria* auct. before him; and his reference in the 'Systema' to "Geoffroy, Paris., 2, p. 255, *Hemerobius*, 3," would bear this out; for Geoffroy clearly indicates the *Sialis*, and the dilatation of the margin of the wings so strongly indicated by him refers to the costal margin; the strong fuscous reticulation also, to my mind, refers to the neuration, and is very applicable to the *Sialis*, as also are the words "ubi sedet tranquilla," and "Sedet alis deflexis uti Phalæna." But there remains the difficulty that *Hemerobius lutarius*, Linné (No. 1513), is represented in his collection by the *Sialis*, that some of his citations for the latter in the 'Systema' equally refer thereto (but not "Schäff. Elem. t. 97," which represents a *Perla*), and that he has added in MS. (to *lutarius*), "De Geer, 2, t. 22. f. 14–15," and "Schäf. Icon. 37. figs. 9–10," which do the same. The confusion appears inextricable, and the suggested relationship of *flavilatera* with the *Hydropsyche* far-fetched.

Tinea Robertella (No. 1394).—That Linné may have described something allied to *Leptocerus* under this name is quite possible, considering the great resemblance many of the species bear to the long-horned Moths; but I would not go so far as to identify *Robertella* with any particular species. The words "antennis albis" appear to be an insuperable objection to its identity with *L. dissimilis*, and almost to its connexion with any true species of *Leptocerus*, although they would apply to species of allied genera.

Having thus fairly stated my objections to some of the results arrived at by Pastor Wallengren, I conclude by remarking that, although I do not feel justified in accepting some of his proposed changes at present, it is but right that his views should be circulated. No more appropriate medium for this purpose could possibly exist than the Journal of the Linnean Society.

New Species of Nudibranchs from the Eastern Seas.

By Cuthbert Collingwood, M.A., M.B., F.L.S.

[Read March 7, 1878.]

(Abstract.)

The author remarks that collectors searching carefully for these naked-gilled Mollusca within a relatively limited locality are, as a rule, more successful in obtaining them than those who hastily traverse wide areas with but a scanty opportunity at each station.

He instances Sir Walter Elliott's series from the coast of Madras, and those of Dr. Kelaart at Ceylon, among which new species greatly preponderate over those of the collections obtained by the eminent naturalists accompanying the voyages of the 'Astrolabe,' 'Samarang,' &c.

The habitat of the Nudibranchs under stones is where they are most often found, but few being met with on the surface of the ocean or swimming about nearer shore; they may, however, be dredged from considerable depths.

The tropics certainly yield the most numerous species of brilliant colour; but on our own coasts there are nevertheless many whose coloration in some respects vies with that of their tropical brethren.

The geographical distribution of some species is not a little remarkable; for instance, the British *Doris tuberculata* is recorded as also to be met with at New Zealand and Vancouver's Island. Dr. Collingwood has himself obtained examples of a species of *Chromodoris* from extreme points in the China Seas.

He relates several instances, showing that Nudibranchiate Mollusca are affected by the season and other causes; for at certain localities where at times they are very abundant, he could not discover a single specimen, spite of the most diligent search.

Curious cases are also mentioned where self-amputation of the creature's own mantle followed its being imprisoned for a night, the salt water being unchanged.

The following is a list of the new species described and figured from the living animals, and which will appear in a forthcoming part of the Society's Transactions:—

Doris pecten. Bush Island, N. Formosa.
—— *crescentica.* China Seas and Borneo.
Chromodoris iris. Makung, Pescadores Islands.

Chromodoris Bullockii. Recruit Island, N. Pacific.
—— *aureopurpurea.* Haitan Straits, China.
—— *tumulifera.* China and Labuan.
—— *tenuis.* Fiery-Cross Reef, China Sea.
—— *funerea.* Labuan, Borneo.
—— *Alderi.* North Formosa.
Albania (n. gen.) *formosa.* Ke-lung Harbour, N. Formosa.
Triopa Principis-Walliæ. Haitan Straits, China.
Trevelyana felis. Island of Ponchou, Pescadores, China.
Doridopsis arborescens. Slut Island, coast of China.
Phyllidia spectabilis. Pulo Barundum, W. Borneo.
Freyeria variabilis. West coast of Borneo.
Bornella marmorata. Aden.

On the Anatomy of Ants*. By Sir JOHN LUBBOCK, Bart., M.P., F.R.S., F.L.S., D.C.L., LL.D., Vice-Chancellor of the University of London.

[Read February 6, 1879.]

(Abstract.)

THE anatomical researches forming this paper are, so to say, an offshoot of the "Observations on the Habits of Ants, Bees, and Wasps," already published at various times in the Society's Journal. It is devoted principally to an exposition of their muscular system, though other parts are discussed, and it is founded on a series of microscopical sections and other preparations. In the introductory remarks the opinions of various entomologists and comparative anatomists are cited with reference to the thorax, and its division into prothorax, mesothorax, and metathorax. The author himself inclines to support Dr. Ratzeburg's views on the subject, who has maintained that the fifth segment of the larva forms not the so-called "scale" or first abdominal segment, but the hinder part of the thorax. The position of the spiracles in ants is commented on as affording strong evidence in support of this opinion.

The internal chitinous appendages appear to divide the thorax

* This memoir in full with suitable illustrations will appear hereafter in the Society's Transactions, the present notice merely glancing at some of the points therein treated.

into four distinct portions, in accordance with which there appear to be four ganglia.

The author then describes minutely the structure of the prothorax from microscopical sections; and a description in detail is given of the muscles of the head and of the legs.

The author calls attention to a structure in ants comparable to that remarkable organ discovered by Von Siebold (1844) in the tibiæ of the front leg of *Gryllus*, and considered by him to serve the purpose of hearing. The recent researches of Dr. V. Graber and others on this subject also receive due notice.

In the tibia of *Lasius flavus* the trachea presents the following arrangement. In the femur it has a diameter of about $\frac{1}{3000}$ of an inch; as soon, however, as it enters the tibia it swells to a diameter of about $\frac{1}{500}$ of an inch, then contracts again to $\frac{1}{800}$, and then again, at the apical extremity of the tibia, once more expands to $\frac{1}{500}$. Moreover as in *Gryllus*, so also in *Formica*, a small branch rises from the upper sac, runs almost straight down to the tibia, and falls again into the main trachea just above the lower sac. The remarkable sacs at the two extremities of the tracheæ in the tibia may also be well seen in other transparent species, such, for instance, as *Myrmica ruginodis* or *Pheidole megacephala*. At the place where the upper tracheal sac contracts, there is, moreover, a conical striated organ, which is situated at the back of the leg. The broad base lies against the external wall of the leg, and the fibres converge inwards. There are indications, though somewhat indistinct, of bright rods.

The posterior portion of the thorax is then described, and the differences which are exhibited in the presence and in the absence of wings pointed out, as also the changes characteristic of the sexes. The postthoracic gland, first observed by Meinert, is then described; and, lastly, the author refers to the muscles which move the abdomen.

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END OF THE FOURTEENTH VOLUME.

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